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NORTH EAST GRASSLAND & FORAGE
CO-OPERATIVE LTD.

White Fox, Saskatchewan

FORAGE PRODUCTION

IN

NORTH EAST SASKATCHEWAN

D-90-CF-0755
89 000 191

Agriculture Development Fund
Projects:

D-89-05-0542
D-90-CF-0755

FINAL REPORT
January 1992

prepared by

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January 6, 1992

Mr. George G. Lidster
President
North East Grassland & Forage Co-operative Ltd
White Fox, Saskatchewan
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Dear George:

Please find enclosed the final report Forage Production in North East Saskatchewan.

It has been a pleasure working with the North East Grassland and Forage Co-operative on this three year project.

Thank you for the opportunity to provide these services to your Association.

Yours truly,

W. Keith Head, P.Ag

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FORAGE PRODUCTION IN
NORTH EAST SASKATCHEWAN

North East Grassland & Forage
Co-operative Ltd.
1992

SYNOPSIS

This is the final report for Agriculture Development Fund projects:

Project D89-05-0542 - Forage Production in North East Saskatchewan

Project D90-CF-0755 - Forage Production in North East Saskatchewan

The North East Grassland and Forage Co-operative Ltd. initiated a three year forage production demonstration project in the spring of 1989. This project was expanded in 1990 under Project D90-CF-0755.

This report represents the completion of activities undertaken in these projects. It includes the details of the 1991 activities and also summarizes the project activities over the three years. Details of the 1989 and 1990 projects are contained in the Interim Reports dated February 1990 and January 1991.

The projects are supported by the Agriculture Development Fund and the members of the Forage Co-operative.

During the three years of these projects, a total of 23 demonstration sites were established and monitored. The projects are located on members' farms located throughout the area from Love to Carrot River and Arborfield.

The Fertility of Alfalfa Project was designed to demonstrate the effectiveness of fertilizers applied to established stands of alfalfa. It involved seven sites in the White Fox, Aylsham, Carrot River, and Arborfield areas. The effect of the fertilizer treatments on dry matter yield, feed quality, tissue nutrient levels, and available soil nutrient levels were monitored for two years.

Broadcast application of phosphorus and potassium fertilizers to existing alfalfa stands increased forage yields in the year of application and in the year following application. In most cases the investment in the fertilizer was not recovered in two years.

The Pasture Fertilization Project was located on three pastures in the White Fox and Carrot River areas. In 1989 three fertilizer rates and two application methods were evaluated for their effects on dry matter yields, feed quality, and soil fertility. In 1990 the same plots received broadcast applications of nitrogen fertilizer. Forage yields were monitored over three years.

The fertilizer treatments increased forage yields at all sites. The yields of forage increased with increased rate of fertilizer. On two of the sites the increased carrying capacity provided net returns of from $8.49 to $35.70 per acre to the investment in fertilizer. Returns on the third site were restricted by lack of timely rainfall and severe grasshopper infestations in 1989 and 1990. "Knifing" fertilizer into the pasture sod reduced forage yields in the year of application due to injury to the pasture by the tillage operation.

The Sod Seeding project included 6 sites seeded in 1989 and 4 additional sites established in 1990. In both years the grass and legume mixtures were seeded with a John Deere All-Till drill following an application of Roundup herbicide to remove the existing vegetation.

The project demonstrated the need for adequate control of the old pasture vegetation, for control of broad leaf weeds in the newly established stands, and for control of grasshoppers in the year of establishment.

The Forage Establishment demonstration included 3 sites on which the seeding rate of the cover crop was varied to measure the effect of cover crop density on the establishment and subsequent yield of forage. Meadow brome established under a low density cover crop was more vigorous and advanced in the establishment year than under high density canopies. Early season growth of the meadow brome in the first year following establishment was enhanced by thin cover crops. By mid-summer, the cover crop density no longer affected the forage yield of the meadow brome.

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1.0 INTRODUCTION

The North East Grassland and Forage Co-operative Ltd. initiated a three year forage production demonstration project in the spring of 1989. The original project (Project # D89-05-0542) was supplemented with a second 1 year project (Project # D90-CF-0755). The second project allowed follow-up of some of the activities initiated under the original project. Project D90-CF-0755 was extended into the 1991 field season. This report covers the demonstration results for 1991 and also summarizes the activities of the past three years under these two projects.

The projects were supported by the Agriculture Development Fund and the members of the Forage Co-operative. The field activities were managed and implemented by Head & Associates Ltd., Nipawin, Sask.

Three demonstration projects were established in 1989 under the initial project. These projects are the Fertility of Alfalfa, the Pasture Fertilization, and the Sod Seeding demonstrations. The Fertility of Alfalfa and the Pasture Fertilization projects were designed to extend for three years. Additional financial support from the Agriculture Development Fund in 1990 allowed the Forage Co-operative to continue with the Sod-seeding demonstration, expand the Pasture Fertilization demonstration, and initiate a Forage Establishment demonstration. The extension of Project D90-CF-0755 into 1991 allowed monitoring of the Forage Establishment and the Sod-Seeding demonstrations during the summer of 1991.

The projects are located on farms located throughout the area from Love to Carrot River and Arborfield. This provides not only a range of soil, climatic and management conditions, but also allows producers to observe demonstrations close to their own operations.

During the three year term of this project, a total of 23 demonstration sites were established and monitored.

2.0 FERTILITY OF ALFALFA

2.1 Introduction

The Fertility of Alfalfa Demonstration is part of Project D89-05-0542. It was designed to demonstrate the effectiveness of fertilizers applied to established stands of alfalfa. The effects of the fertilizer were to be measured in the year the

fertilizer was applied, and for the two years following application. The effectiveness of copper fertilizer on alfalfa production was also evaluated.

2.2 Project Design

Seven sites were selected in the spring of 1989. These sites are located in the White Fox, Aylsham, Carrot River, and Arborfield areas (Table 1). The alfalfa fields are managed either for hay production or for the production of dehydrated alfalfa pellets.

Each site consists of 2 fertilizer test plots and an unfertilized check plot. The plots run the length of the field and are each 100 feet wide.

Table 1: Co-operators and site locations for the Fertility of Alfalfa Project

G. Britton	NW 13-49-13-W2
A. Ginter	SE 24-49-12-W2
E. Johansen	SW 7-48-10-W2
B. Meyer	SW 10-49-10-W2
A. Munro	SW 7-52-14-W2
T. Reavie	NE 1-48-11-W2
L. Wood	NW 27-49- 8-W2

The fertilizer treatments were broadcast on April 28, 1989 using a boom-type, air-flow dry fertilizer spreader. This insured uniform application of the fertilizer on the plots.

The two fertilizer treatments contained the following nutrient levels:

Treatment 1. 30 N - 25 P_2O_5 - 60 K_2O - 30 S

Treatment 2. 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Copper

2.3 Yield and Quality Measurements

The fertilizer treatments were evaluated in terms of their effects on forage yield, forage quality, and nutrient levels in the plant tissues.

Square metre yield samples were collected from 5 replicates in each plot. Each sampling site was selected such that the landscape position was as uniform as possible across the plots. Sample collection was coordinated with the commercial harvest operations on the dehy fields and the haying operations on the hay fields.

The yield samples were weighed, moisture contents determined, and yields calculated on the basis of tons of dry matter per acre.

Feed samples were collected from each plot during the second harvest. These samples were air-dried and submitted to the Saskatchewan Feed Testing Laboratory for analyses.

Tissue samples were collected from each of the plots during the second harvest. The samples were air-dried and submitted to the Saskatchewan Soil Testing Laboratory for analyses.

Soil samples were taken from each site in the spring of 1989 and from each plot in the fall of 1989 and 1990.

2.4 Observations

In 1989 the plots were harvested either two or three times depending on the harvest schedule for the field. In 1990, the plots were each harvested twice, except for the Johansen plot which was worked up after the first cut.

In 1991, due to low plant populations and depressed alfalfa prices, the fields on which the plots were located were scheduled to be taken out of alfalfa production. Consequently, no yield samples could be collected. The observations reported here are a summary of the yield measurements from two years, rather than three as originally planned.

2.4.1 Yield Response

The objective of this part of the project was to demonstrate the effect of "one-shot' applications of phosphorus, potassium, and copper fertilizers on the yields of alfalfa forage over more than one growing season.

Soil tests taken at the beginning of the project indicated that yield responses to the phosphorus fertilizer should occur on the Britton, Ginter, Meyer, and Munro sites. The remaining sites had adequate soil reserves of phosphorus. The Britton, Ginter, and Meyer sites were expected to respond to the potassium fertilizer. Only the Britton and the Munro site were expected to respond to the copper fertilizer. The Johansen, Reavie and Wood sites all had adequate plant nutrients and were not expected to provide significant responses to the fertilizer treatments.

Total alfalfa yields for the two years for each site are presented here (Table 2). Detailed yield data for each of the two years of harvests are available in the Interim Reports prepared for 1989 and 1990.

All of the sites, including those with adequate soil nutrients, tended to provide positive yield responses to the phosphorus and potassium fertilizers. These responses were relatively small, but did occur in both years, indicating that there was residual value to the fertilizers in the years following application. These responses were, however, relatively small and did not cover the costs of the fertilizer inputs. The opportunity for yield response was limited in both 1989 and 1990 by inadequate rainfall. In 1989, early season rainfall was limited so first cuts were small. In 1990 very little rainfall occurred after July 1, so although the first cuts were generally good, the second harvest yielded poorly.

Yield responses to the copper fertilizer were low and not consistent with soil test levels of copper. The Munro site which had marginal soil copper levels did give a small response to the copper fertilizer. The Britton site, that was expected to respond to copper, did not show as large a response as the Munro site. Yield depressions due to the copper fertilizer were also observed on some of the sites. This may be due in part to imbalances between copper and other micronutrients as a result of the copper additions.

2.4.1.1 Britton Site

Total alfalfa yields over the two years at the Britton site were 3.29 tons dry matter (DM)/acre for fertilizer Treatment 1, 3.47 tons DM/acre for Treatment 2, and 3.08 tons DM/acre for the unfertilized Check (Figure 1).

These yields indicate that there was some response to the fertilizer applications, however, the total yield increase was small considering the relatively low soil nutrient levels and the amount of fertilizer applied.

This site was also expected to respond to the copper fertilizer applied in Treatment 2. The yield response for Treatment 2 was small and cannot be attributed directly to the copper fertilizer based on these yield results.

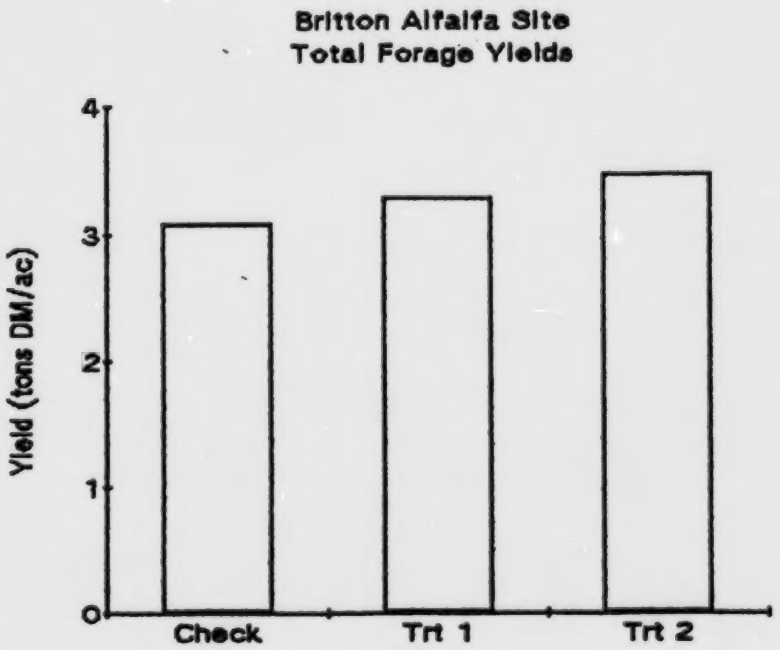

Figure 1. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Britton Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.1.2 Ginter Site

The Ginter site recorded the largest yield increase over the two years of any of the alfalfa sites. Treatment 1 out-yielded the Check by 1.44 tons DM/acre over the two years (Figure 2). This field was the least fertile in terms of phosphorus and potassium according to initial soil test results. The relatively good responses to these nutrients confirms these test levels.

Treatment 2 (containing copper) did not produce as well as Treatment 1. It out produced the Check by only 0.72 tons DM/acre. It would appear as though the copper fertilizer actually depressed yields. This site had received a blanket application of copper fertilizer in the mid 1980's. Soil tests indicate that the additional copper has caused changes in the manganese to copper ratio (Mn/Cu) in the soil. This ratio has been shown to affect barley yields, and appears to also be important for alfalfa growth.

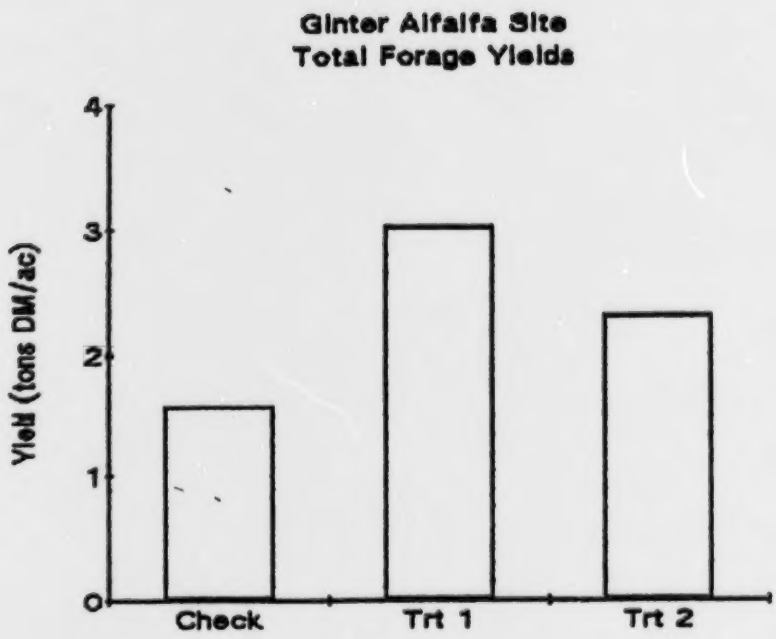

Figure 2. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Ginter Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.1.3 Johansen Site

The Johansen site was plowed down after the first harvest in 1990. Consequently, yield responses and the economic analysis are based on only three cuts, two in 1989 and one in 1990. Even so, the total yield response to the phosphorus and potassium fertilizers in Treatment 1 was the third highest noted in this project. Treatment 1 out yielded the Check by 0.88 tons DM/acre. The copper in Treatment 2 again appears to have caused yield losses relative to Treatment 1, although this plot still out-performed the Check by 0.26 tons DM/acre (Figure 3).

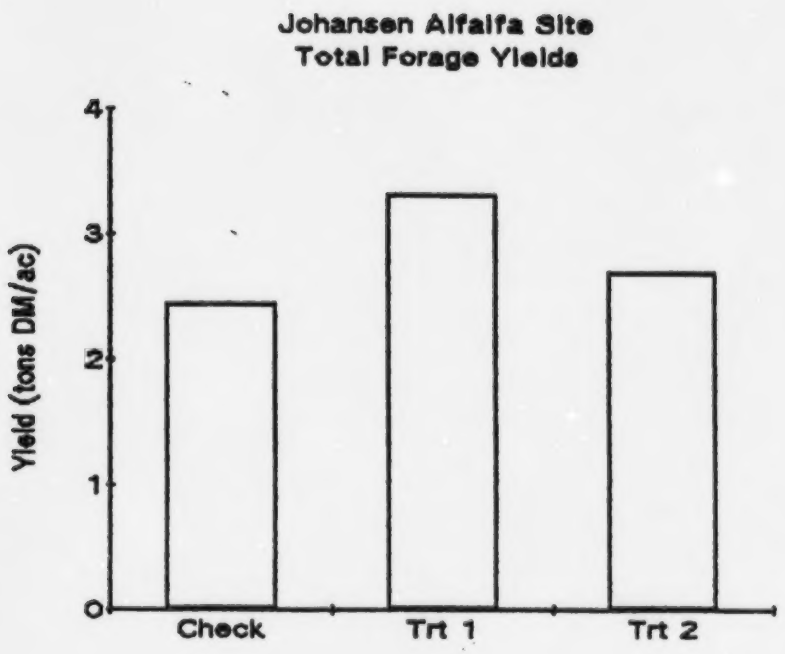

Figure 3. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Johansen Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

Table 2. Effect of fertilizer treatments on the two year total alfalfa forage yields.

PLOT	YEAR	YIELD (TONS DM/ACRE) TRTMT 1	TRTMT 2	CHECK
BRITTON	1989	2.17	2.21	1.77
	1990	1.12	1.26	1.31
	TOTALS	3.29	3.47	3.08
GINTER	1989	1.52	1.16	0.84
	1990	1.51	1.15	0.75
	TOTALS	3.03	2.31	1.59
JOHANSEN	1989	2.24	1.95	1.80
	1990	1.08	0.73	0.64
	TOTALS	3.32	2.68	2.44
MEYER	1989	1.26	1.33	1.04
	1990	0.61	0.61	0.37
	TOTALS	1.87	1.94	1.41
MUNRO	1989	1.20	1.43	1.13
	1990	1.25	1.48	1.18
	TOTALS	2.45	2.91	2.31
REAVIE	1989	2.46	2.34	1.81
	1990	1.61	1.74	1.18
	TOTALS	4.07	4.08	2.99
WOOD	1989	1.46	1.36	1.23
	1990	0.65	0.51	0.49
	TOTALS	2.11	1.87	1.72

2.4.1.4 Meyer Site

The fertilized plots at the Meyer site both out yielded the Check (Figure 14). Treatment 1 produced 0.46 tons DM/acre more over the two years than the Check (Figure 4). At this site, the copper in Treatment 2 did not depress yields relative to Treatment 1 as was observed at Ginter, Johansen, and Wood sites. Treatment 2 produced a slightly larger yield increase (0.53 tons DM/acre) than did Treatment 1.

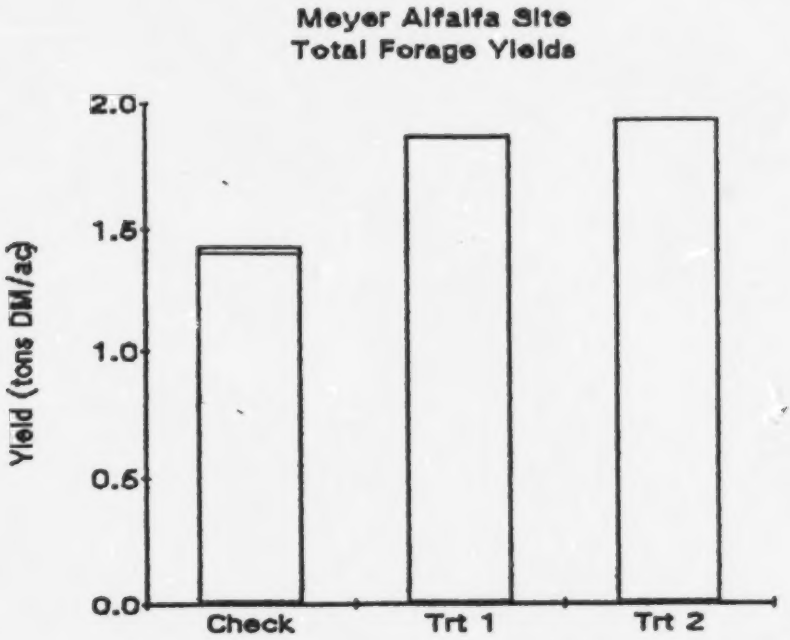

Figure 4. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Meyer Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.1.5 Munro Site

Total forage yields over the two years of sampling indicate that the fertilizer treatments consistently produced more than the unfertilized check strip. This is also the only site at which the copper fertilizer in Treatment 2 appears to have caused a significant yield increase. Treatment 2 produced 0.60 tons DM/acre more than the Check, while Treatment 1 produced only 0.14 tons more than the Check over the two years (Figure 5).

Soil tests indicated that phosphorus was only marginally deficient and potassium levels were adequate. The small response to the phosphorus and potassium in Treatment 1 was to be expected. The soil copper levels were considered marginal and responses to copper would not be expected to be large. However, under the conditions of this demonstration, yields were improved by the addition of copper fertilizer.

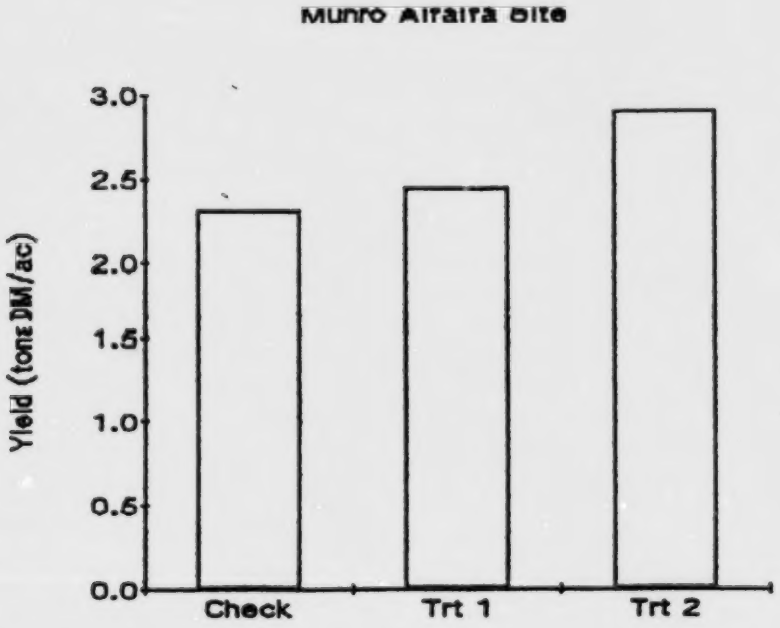

Figure 5. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Munro Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.1.6 Reavie Site

The Reavie site produced the second largest forage yield response over the two years of sampling. Treatment 1 produced 1.08 tons DM/acre more than the Check over the two years (Figure 6). This yield response again cannot be explained by soil test data. The Reavie site is one of the more fertile of the sites in this demonstration project so yield increases due to fertilizer would be expected to be minimal. The unusual response may relate to better reserves of soil moisture available in the clay loam soils of this site, or perhaps to timely rains during the growing seasons.

The copper in Treatment 2 had no effect on forage yields.

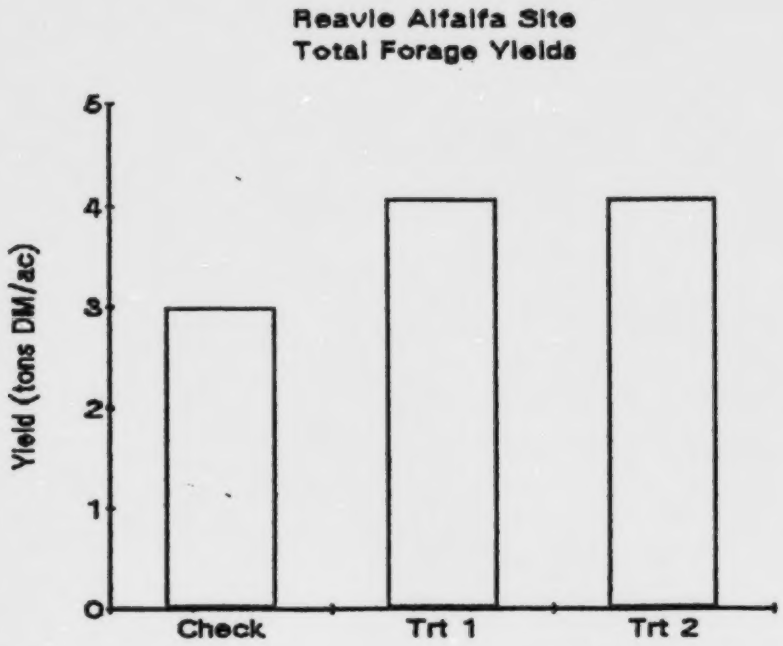

Figure 6. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Reavie Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.1.7 Wood Site

Yields over the two years indicate that the fertilized plots marginally out-performed the unfertilized Check. Treatment 1 provided 0.39 ton DM/acre more than the Check over the two years. The copper fertilizer in Treatment 2 appears to have depressed forage yields. Treatment 2 yielded only 0.15 tons more than the Check (Figure 7).

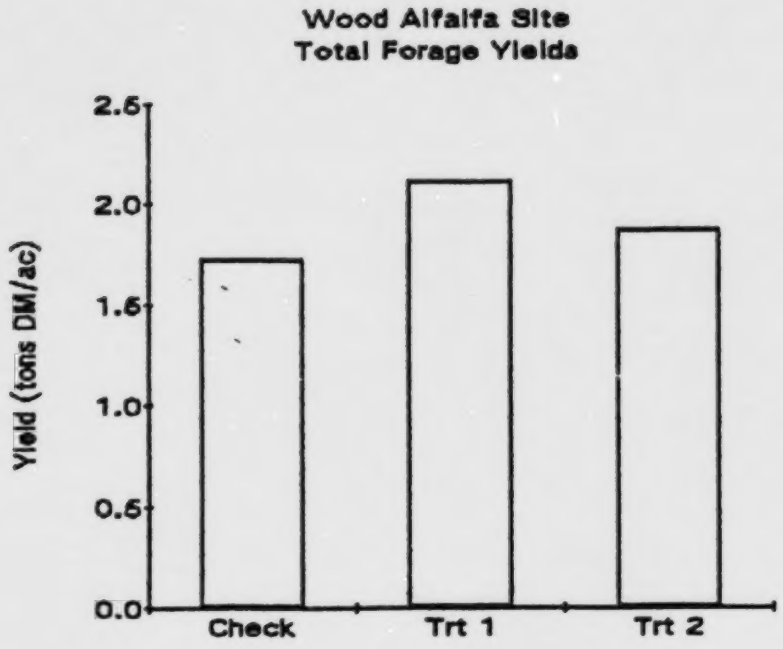

Figure 7. Effect of fertilizer applied in 1989 on the two year total alfalfa forage yield at the Wood Site.
Trt 1: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 0 Cu;
Trt 2: 30 N - 25 P_2O_5 - 60 K_2O - 30 S - 5 Cu.

2.4.2 Forage Quality

Analyses of feed samples (100% dry matter basis) taken during the second harvest in both 1989 and 1990 indicate no significant changes in the nutrient

content of the forage due to the fertilizer treatments (Appendix 3 & 4).

Protein contents on the treatments and the check were all well above the 12-14% considered necessary for cattle. Phosphorus levels were increased marginally by the addition of P fertilizer, but still did not approach the 0.35% required for rations. As well, the Calcium/Phosphorus ratio in all samples were well above the 4:1 level considered optimum for rations. Phosphorus supplements would be required for adequately balanced rations based on the alfalfa hay.

The phosphorus levels were the lowest on the sights that had the lowest soil available phosphorus levels ie. the Britton and Munro sites.

The copper fertilizer did not have a significant or consistent effect on copper levels in the forage. Copper levels were marginal in all samples. Mineral supplements with significant copper contents would be required for rations based on the alfalfa hay.

The TDN levels exceeded 60% in all the samples, and were not affected by the fertilizer treatments.

2.4.3 Soil and Tissue Tests

Soil samples taken in the fall of 1989 and 1990 indicate that the fertilizer applications had very little effect on the soil nutrient levels and the fertilizer recommendations (Appendix 1 & 2).

Soil available phosphorus levels in the Check plots on the Britton, Munro and wood sites are lower than they were in 1989, while the levels in fertilized plots have not changed. This may reflect the crop removal of phosphorus that has been compensated for by fertilizer applications. However, care must be exercised in drawing conclusions based on one year of soil sampling due to the highly variable nature of soils.

Tissue samples taken during the second harvest in each year indicate that nutrient uptake is generally within the established guidelines for adequate plant nutrition (Appendix 5 & 6). Levels of nutrients in the plant tissue have not been consistently affected by the fertilizer applications. Samples from the Britton and Ginter sites indicate that the nitrogen levels in the tissue are below that considered adequate for efficient alfalfa growth. This may reflect decreased nitrogen fixation by the alfalfa.

The Reavie and Wood sites had adequate nutrients according to the soil samples even before the fertilizer applications. This was also confirmed by the tissue samples.

2.4.4 Economic Evaluation

A detailed economic summary was prepared in the Interim report following the second year of the project (Interim Report, January 1991). As no further yield measurements were possible in 1991, no additional economic analyses were possible. A brief summary of the results is provided here.

The net return to the fertilizer applications were calculated on the basis of $35.00/ton for the alfalfa hay and the total costs of the fertilizer and application charges in 1989. Carrying charges at a rate of 15% per annum on the net losses incurred in 1989 were added to the fertilizer costs. No extra fertilizer was added in 1990.

The results of this demonstration project indicate that large, single dose applications of fertilizer to existing alfalfa stands involves significant economic risks. Although the phosphorus and potassium fertilizer treatments (Treatment 1) generally increased total forage yields over the two years, the yields in most cases were too small to cover the total costs of the fertilizer and the carrying charges on the fertilizer investment.

Only two of the sites showed a net profit to the fertilizer application after two years. The Ginter site recorded a net profit of $16.42/acre and the Reavie site returned a profit of $3.66/acre (Table 3). On all the other sites except the Britton site, the yield increases over the two years have covered the cost of the carrying charges and a portion of the capital invested in fertilizer. There is a possibility, therefore, that the residual yield increases over time may pay for the fertilizer inputs. However, it is unlikely that the pay-back would occur during the life of the alfalfa stand.

At all sites, Fertilizer Treatment 2, which included an application of copper, recorded net losses over the two years of from $10.00 to $45.00 per acre. This suggests that any yield losses due to low soil levels of copper are not large enough to warrant the application of copper fertilizer under the conditions

of this demonstration. Yield responses to copper may not be occurring due to imbalances of copper with other micronutrients such as manganese. As well, feed analyses suggest that copper fertilization does not increase the levels of copper in the forage so no improvement in feed quality was obtained by the application of copper fertilizer.

Table 3. Net return (net loss) to fertilizer applications on alfalfa plots.

	BRITTON	GINTER	JOHANSEN	MYER	MUNRO	REAVIE	WOOD
TRTMT 1	($28.10)	$16.42	($4.44)	($20.29)	($32.28)	$3.66	($22.69)
TRTMT 2	($35.16)	($24.24)	($41.93)	($31.04)	($28.54)	($10.18)	($45.19)

2.5 Summary

Broadcast applications of phosphorus and potassium fertilizers to existing alfalfa stands provided increases in forage yields in the year of application and in the year following application. The size of the yield increases was variable among sites and between years. Climatic conditions, particularly the timeliness of adequate rainfall can significantly over shadow the effects of fertilizer on forage yields. Consequently, large, single dose applications of fertilizer to alfalfa stands involves considerable economic risk. Smaller fertilizer applications applied more frequently and on the basis of growing conditions may reduce the economic risks.

Yield increases due to the copper fertilizer in Treatment 2 were variable and not consistent with either soil copper levels or tissue levels. In no instance did the increased yield cover the outstanding costs of the fertilizer and at only two sites were the balances reduced.

On the basis of this demonstration project the application of expensive micronutrients to alfalfa is not economically viable. Soil test results do not appear to indicate which fields will respond to copper fertilizers and which will not. Additional scientific

research is required to more accurately determine critical soil micronutrient levels for forage production, as well as the interactions of the micronutrients among themselves and with the macronutrients.

The fertilizer treatments did not have significant effects on the quality of the forage. Feed analyses did, however indicate that phosphorus levels were generally lower in the forage grown on sites with low soil phosphorus levels.

3.0 PASTURE FERTILIZATION

3.1 Introduction

The Pasture Fertilization Project was designed to demonstrate the effectiveness of fertilizers applied to established pastures. The sites were established in 1989 and forage yields monitored for three years.

3.2 Project Design

Only two of the three pasture sites selected in 1989 were available in 1990. The Trew site suffered severe winter-kill and had to be abandoned. The Black site was established in the spring of 1990 to replace the Trew site (Table 4).

Table 4. Co-operators and site locations for the Pasture Fertilization Project

G.A. Lidster	SW 17-53-13-W2
R. Nicklen	SW 18-50-10-W2
J. Black	NW 19-48-10-W2

3.2.1 Lidster Site

The Lidster site at White Fox is a "native" quack grass stand on very sandy soils of low production potential. This site received three different rates of nitrogen, phosphorus, potassium, and sulfur in 1989. In 1990 the same plots received additional nitrogen and sulfur fertilizers. In 1991, no additional fertilizer was applied to the plots.

In 1989 the fertilizer treatments were:

Plot 1: 30 N - 12 P_2O_5 - 30 K_2O - 5 S

Plot 2: 60 N - 25 P_2O_5 - 60 K_2O - 10 S

Plot 3: 90 N - 38 P_2O_5 - 90 K_2O - 15 S

Check: No fertilizer applied

In 1990 fertilizer was applied to the same plots at the following rates:

Plot 1: 30 N - 10 S

Plot 2: 60 N - 19 S

Plot 3: 90 N - 29 S

Check: No fertilizer applied

The fertilizer treatments were applied early in the spring of each year by means of an air-flow, boom-type, dry fertilizer applicator.

In 1991 no further fertilizer was applied to the plots.

3.2.2 Nicklen Site

The Nicklen site is on a pasture originally seeded to brome grass about 20 to 25 years ago. On this site two methods were used to apply the fertilizer in 1989. One involved banding the fertilizer into the sod with a knife-equipped air seeder. The second was by broadcasting the fertilizer on the surface. In 1990, the fertilizer was broadcast on all of the plots, including the "banded" plot.

In 1989 the fertilizer treatments were:

Banded. 50 N - 0 P_2O_5 - 30 K_2O - 10 S

Plot 1. 90 N - 40 P_2O_5 - 60 K_2O - 0 S

Plot 2. 70 N - 30 P_2O_5 - 45 K_2O - 0 S

Plot 3. 45 N - 20 P_2O_5 - 30 K_2O - 0 S

Check. No fertilizer applied

In 1990 the same plots received the following fertilizer applications. The fertilizer applied to the

"banded plot" in 1990 was broadcast, not banded as it was in 1989.

Banded. 60 N - 19 S

Plot 1. 90 N - 29 S

Plot 2. 60 N - 19 S

Plot 3. 30 N - 10 S

Check. No fertilizer applied

In 1991 no further fertilizer was applied to the plots.

3.2.3 Black Site

The Black site was established in 1990 to replace the Trew site that was abandoned in 1989. The Black pasture site supports a 20+ year old stand of brome grass on Gray-Black sandy loam soils northeast of Arborfield.

At the Black site the fertilizer treatments in both 1990 and 1991 were broadcast at the rates of:

Plot 1. 25 N

Plot 2. 50 N

Plot 3. 75 N

Check. No fertilizer applied

3.3 Yield and Quality Measurements

Wire "growth cages" covering 1 square yard were installed in each plot. At the Lidster site 6 cages were located in each plot in 1989. In 1990 this number was reduced to 5 per plot. At the Nicklen site 4 cages were located in each plot in both 1989 and 1990. The Black site had 3 cages in each plot.

Yield samples were collected from the growth cages twice during the growing season in 1989 and 1990. In 1991 three harvests were collected. The samples were

weighed, moisture contents determined, and the yields calculated on a dry matter basis. The yields from the individual cages in each plot were used to determine an average yield for each harvest. The average yields were combined to provide the total yield of forage from each plot for the year.

Feed samples were collected during the second harvest each year and submitted to the Saskatchewan Feed Testing Laboratory for analysis.

3.4 Observations

NOTE: ERRORS WERE MADE IN THE 1990 YIELD CALCULATIONS FOR THE LIDSTER AND BLACK SITES.

As a result, the yield data presented in Tables 5 and 6 (pages 23 and 24 in the Interim Report, January, 1991) contain some errors. As well, the economic analyses of the Lidster and Black sites based on these yield data and presented in Table 8 (page 25 in the Interim Report, January, 1991), are also inaccurate.

The corrected yield data for the 1990 pasture yields of the Lidster and Black sites are presented herein (Tables 5, & 6). These revised data are also used in the final yield and economic analyses for these sites as presented in this final report.

Table 5. Effect of fertilizer treatments on pasture forage yields at the Lidster site in 1990. The yield for each harvest is the average of 5 replicates.

SITE	HARVEST	DATE	YIELD (TONS DM/ACRE) PLOT 1 30 N	PLOT 2 60 N	PLOT 3 90 N	CHECK 0 N
LIDSTER	1	Jun 13/90	0.21	0.34	0.51	0.11
	2	Sep 20/90	0.14	0.14	0.22	0.09
	TOTALS		0.35	0.48	0.73	0.20

Table 6. Effect of fertilizer treatments on pasture forage yields at the Black site in 1990. The yield for each harvest is the average of 3 replicates.

SITE	HARVEST	DATE	YIELD (TONS DM/ACRE) PLOT 1 25 N	PLOT 2 50 N	PLOT 3 75 N	CHECK 0 N
BLACK	1	Jul 2/90	0.43	0.33	0.45	0.23
	2	Aug 8/90	0.28	0.35	0.41	0.18
	TOTALS		0.71	0.68	0.86	0.41

3.4.1 Lidster Site

3.4.1.1 1991 Yield Results

As no extra fertilizer was applied to the test plots at the Lidster site in 1991, any yield responses relative to the Check plot would have to be a result of the residual fertilizers applied in 1989 and 1990.

Some yield increases were noted on the plots receiving the largest amounts of fertilizer in 1989 and 1990 (Figure 8), although no visual responses were apparent (Figure 16). The yield increases over the Check were small. They likely could be attributed to the residual fertilizer. The yield increases were not as large as in 1990 (Table 7), at which time nitrogen and sulphur fertilizers were applied.

Grasshopper infestations were not as severe in 1991 as in the previous years, however, there was still likely a negative effect on forage yields due to grasshoppers.

Table 7. Three year total forage yields at the Lidster Pasture site.

		YIELD (TONS DM/ACRE)			
SITE	YEAR	PLOT 1	PLOT 2	PLOT 3	CHECK
LIDSTER	1989	0.45	0.53	0.61	0.41
	1990	0.35	0.48	0.73	0.20
	1991	0.58	0.83	0.75	0.64
	TOTALS	1.38	1.84	2.09	1.25

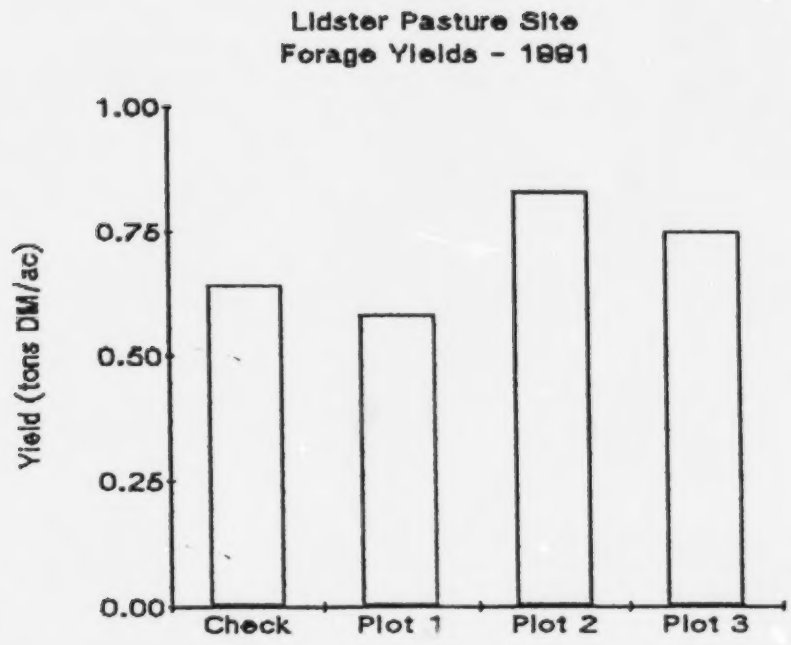

Figure 8. Effect of fertilizer on forage yields at the Lidster Site in 1991.

3.4.1.2 Three Year Total Forage Yields

The total yield of forage from the test plots over the three years of the project indicated a typical response to fertilizer applications. That is, increasing amounts of fertilizer resulted in higher yields, but the amount of the yield increases became smaller at the higher rates of fertilizer (Figure 9).

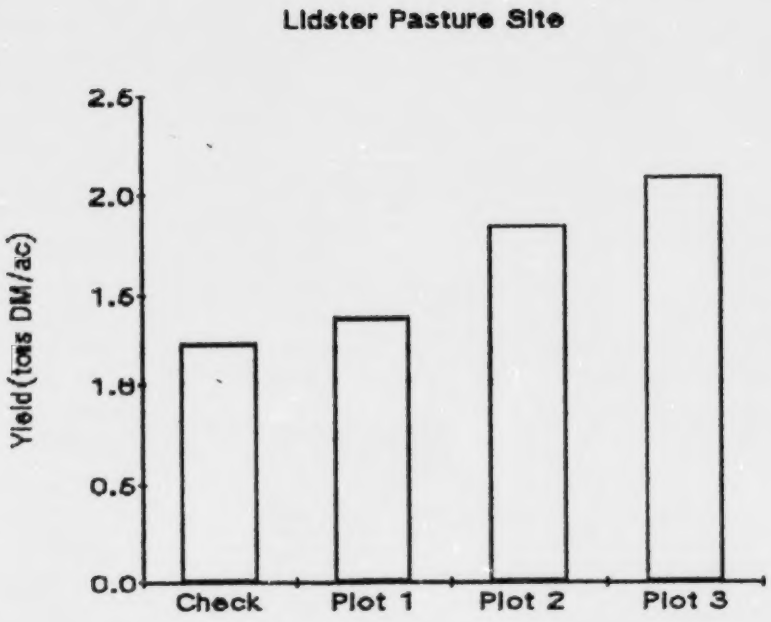

Figure 9. Three year total forage yields at the Lidster Site.

The total amount of forage produced on the plots over the three years was however, relatively low (Table 7). The average annual yield ranged from 0.42 tons/acre on the Check plot to only 0.70 tons/acre on Plot 3, which received the highest rates of fertilizer. These low yields can be attributed in part to two factors, both of which are not usually considered a major concern in the Gray soil zone. The first was relatively low precipitation during the early part of the growing season in 1989. The second, and more devastating, was severe infestations of grasshoppers in both 1989 and 1990.

In 1989, very little precipitation occurred at the Lidster site prior to July. As a result, the usual flush of spring growth did not occur, nor was there an opportunity for utilization of the fertilizer applied in April. Yields obtained at the first clipping did not exceed 0.22 tons/acre, and the lowest was 0.12 tons on the Check plot. By June of 1989, grasshopper populations at the Lidster site were extreme. New growth was consumed as quickly as it appeared

(Figure 17). No attempt to clip the plots was made until September. At that time the highest yielding plot produced only 0.17 tons/acre.

In 1990, the early season moisture was much better than in 1989. Responses to the fertilizer applied in April of 1990 were quite visible (Figure 15). Yields from the first clipping on June 17 reflected this response with yields of up to 0.51 tons/acre, which were considerably higher than in 1989. However, the grasshoppers again devastated the pasture throughout the summer, with yields from the September clipping not exceeding 0.2 tons/acre even on the Plot receiving the highest rate of fertilizer.

In comparison, rainfall in May and June of 1991 was good, and grasshopper populations were lower. Forage yields were the highest in 1991, even though no fertilizer was applied that year (Table 7) and visual responses did not occur (Figure 16).

3.4.2 Nicklen Site

3.4.2.1 1991 Yield Results

No fertilizer was applied to the Nicklen plots in 1991. Yield increases measured in 1991 can be attributed to the residual effects of the fertilizers applied in 1989 and 1990.

All of the plots showed higher yields than the unfertilized Check (Figure 10). However, the largest yield increase occurred on the plot that had received the least amount of fertilizer. Plot 1, that had received the largest amount of fertilizer in the two previous years yielded the lowest of the fertilized plots. No explanation is available for these responses.

The yield increases measured in 1991 were considerably smaller than in the previous years when fertilizers were applied in the spring. Yield increases ranged from less than 0.1 ton/acre to a high of 0.3 tons/acre in 1991, while in the previous years yield increases were generally around 0.5 tons/acre (Table 8). It is obvious that the residual effects of the fertilizers are not nearly as dramatic as the initial effects of annual applications of fertilizer.

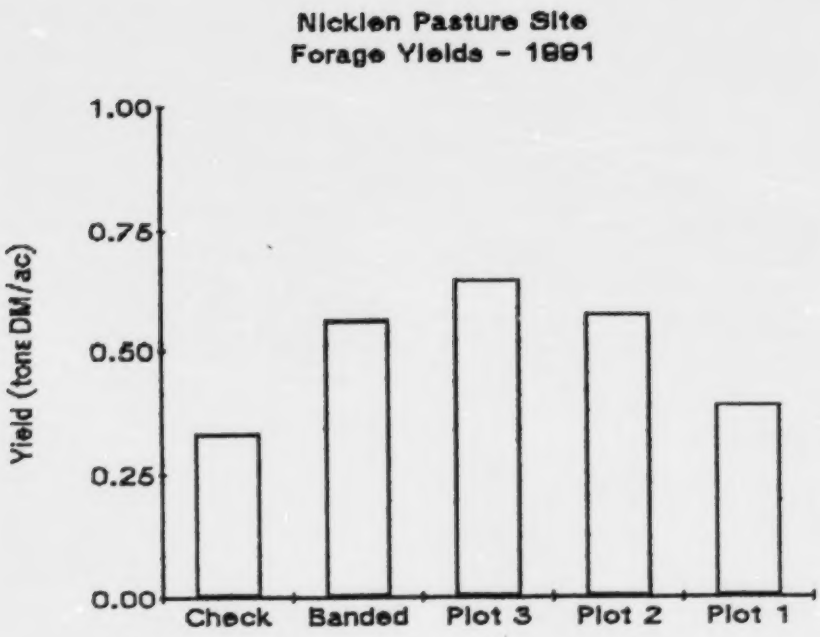

Figure 10. Effect of fertilizer on forage yields at the Nicklen Site in 1991.

3.4.2.2 Three Year Total Forage Yields

Over the three years that the yields were measured on the Nicklen plots, the fertilized plots produced about 1.0 to 1.5 tons/acre more than the unfertilized Check plot. The total forage yields increased with increasing rates of fertilizer, except for Plot 1 which received the highest rate of fertilizer. Total yield of forage on that Plot was about 0.5 tons/acre less than on the highest yielding plot (Figure 11).

The "Banded" Plot, on which the fertilizer was knifed into the sod in 1989, provided similar residual yields as the other Plots on which the fertilizer was surface broadcast. However, because of the relatively low yields obtained in the year of banding (Figure 18), total yields from this method of application were the smallest of all the Plots (Table 8).

Table 8. Three year total forage yields at the Nicklen Pasture site.

SITE	YEAR	YIELD (TONS DM/ACRE) BANDED	PLOT 1	PLOT 2	PLOT 3	CHECK
NICKLEN	1989	0.47	0.94	1.03	0.96	0.30
	1990	0.92	0.76	1.00	0.80	0.45
	1991	0.57	0.39	0.58	0.65	0.33
	TOTALS	1.96	2.09	2.61	2.41	1.08

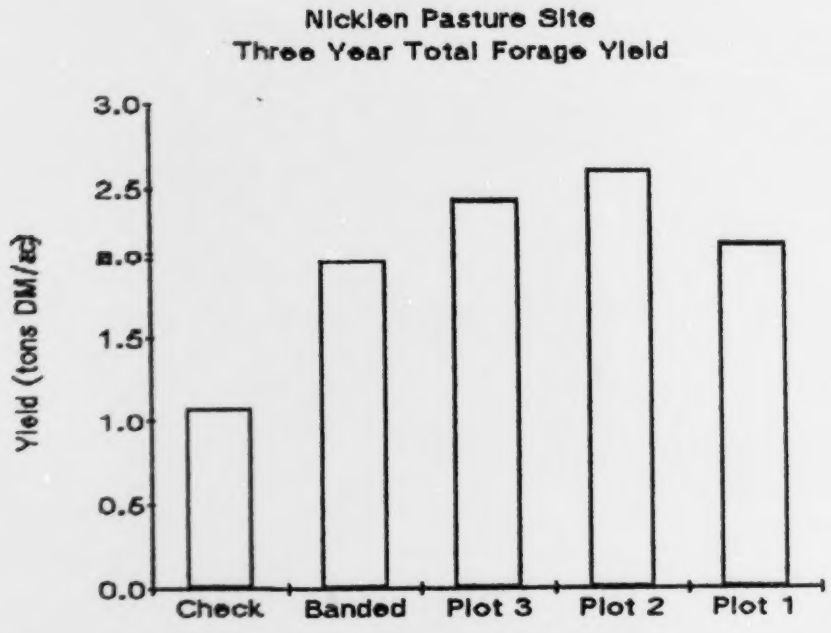

Figure 11. Three year total forage yields at the Nicklen Site.

3.4.3 Black Site

3.4.3.1 1991 Yield Results

Increases in forage yields as a result of the fertilizer treatments were much larger in 1991 than in 1990. The increases ranged from 0.7 to 0.9 tons/acre (Table 9).

The forage yields at the Black site increased as the amount of fertilizer was increased. However, the amount of the yield increases got smaller as the fertilizer rates increased (Figure 12). The first 25 pounds of Nitrogen added to Plot 1 resulted in a yield of 0.7 tons/acre more than the Check Plot. However, Plot 2, which received 25 pounds of Nitrogen more than Plot 1, only produced 0.3 tons/acre more than Plot 1. And, Plot 3, which received 25 pounds of Nitrogen more than Plot 2, produced a mere 0.1 tons/acre more forage than Plot 2. This phenomenon is referred to as the "Law of Diminishing Returns" which states that the yield increase for each additional fertilizer increment will be less than for the previous fertilizer increment. In other words, yields cannot be increased indefinitely by the addition of extra fertilizer. Other factors can limit yield. In this case, the moisture deficit during parts of the growing season no doubt limited the yields on the plots receiving the high rates of fertilizer. The Law of Diminishing Returns has a very significant effect on the economic returns to fertilizer applications.

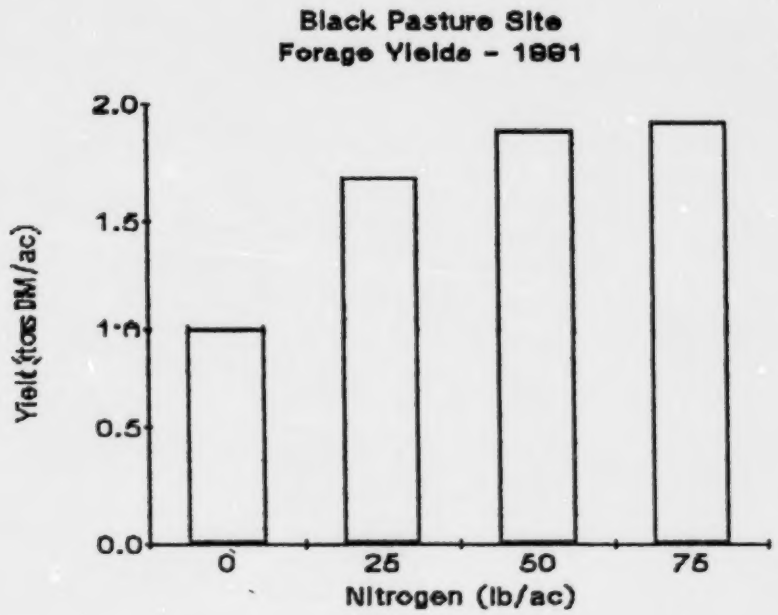

Figure 12. Effect of fertilizer on forage yields at the Black Site in 1991.

3.4.3.2 Two Year Total Forage Yields

Total forage yields over the two years of testing at the Black site indicate a significant response to the fertilizer inputs (Figure 13). Yield increases range from 1.0 to 1.4 tons/acre, with the highest total yields occurring on the plots receiving the highest rates of fertilizer.

Forage yields in 1991 were considerably better than in 1990. The yield on the Check Plot was 0.6 tons/acre higher in 1991 than in 1990, indicating that growing conditions were much better in 1991 (Figure 19). The fertilized Plots each produced about 1.0 tons/acre more in 1991 than they did in 1990 (Table 9).

Table 9. Two year total forage yields at the Black Pasture site.

SITE	YEAR	YIELD (TONS DM/ACRE) PLOT 1	PLOT 2	PLOT 3	CHECK
BLACK	1990	0.71	0.68	0.86	0.41
	1991	1.69	1.89	1.93	1.00
	TOTALS	2.40	2.57	2.79	1.41

The total forage yields over the two years also conformed to the Law of Diminishing Returns, indicating that there was likely inadequate moisture over the two years to efficiently utilize all of the nitrogen fertilizer inputs (Figure 13).

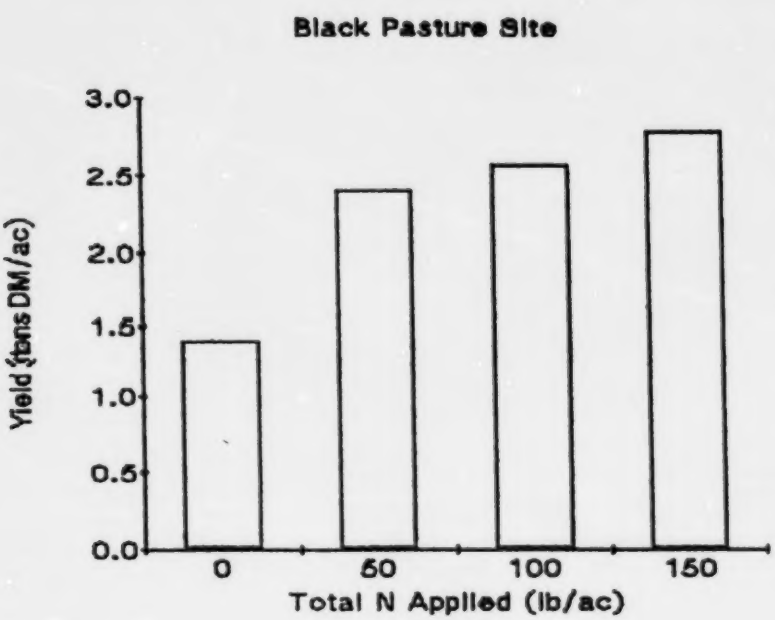

Figure 13. Two year total forage yields at the Black Site.

3.5. Economic Evaluation

On the pastures that were not affected by drought or grasshoppers, the fertilizer inputs provided significant economic returns over the term of the project.

The economic returns were calculated on the basis of the potential increase in beef production from the increased yield of forage on the pasture as a result of the fertilizer applications. The ratio of dry matter intake to the weight gain in cattle was set at 15:1, that is it takes 15 pounds of forage to produce 1 pound of weight gain in either a feeder or a cow/calf unit on pasture. The gain in weight of the cattle was valued at $0.35/pound.

Based on these assumptions, all the pastures except the Lidster site, provided reasonable economic returns over the term of the project (Table 10).

Table 10. Increase in total forage yields and net return (net loss) to fertilizer applications on established pastures.

SITE	PLOT	TOTAL FORAGE YIELD INCREASE lb DM/acre	TOTAL CATTLE WEIGHT GAIN * lb/acre	VALUE OF WEIGHT GAIN ** $/acre	COST OF FERTILIZER $/acre	NET RETURN $/acre
LIDSTER	1	260	17.3	$6.07	$28.74	($22.67)
	2	1180	78.7	$27.53	$53.01	($25.48)
	3	1680	112.0	$39.20	$77.75	($38.55)
NICKLEN	BANDED	1760	117.3	$41.07	$32.58	$8.49
	1	2020	134.7	$47.13	$63.00	($15.87)
	2	3060	204.0	$71.40	$43.93	$27.47
	3	2660	177.3	$62.07	$26.45	$35.62
BLACK	1	1980	132.0	$46.20	$10.50	$35.70
	2	2320	154.7	$54.13	$20.96	$33.17
	3	2660	177.3	$62.07	$31.04	$31.03

* Assumes that 1 pound of live cattle weight gain is obtained from 15 pounds of forage

** Live cattle weight gain is valued at $0.35 per pound

The Lidster site suffered losses ranging from $22.67 to $38.55/acre. These losses were a result of the drought conditions in 1989 and the grasshopper infestations in both 1989 and 1990.

The Nicklen site showed positive returns to the fertilizer, except on Plot 1 which received $63.00/acre worth of fertilizer. Plot 1 had a net loss of $15.87 as a result of very low forage yields over the three years.

The Black site was the most profitable of the three sites. Over two years the Black site returned up to four times the investment in fertilizer. Net returns ranged from $31.03 to $35.70 (Table 10).

On all sites, the largest net returns were to the lowest fertilizer inputs. This is because the yield increases per unit of fertilizer were largest at the low levels and decreased as fertilizer inputs increased. This follows the Law of Diminishing Returns and indicates that at the higher levels of fertilization, other factors such as growth characteristics of the grasses or drought conditions limited the forage yields.

3.6 Summary

The Pasture Fertilization Project demonstrated to forage producers the effects of large and small applications of fertilizer on the yield of pasture hay and some of the risks involved in investing in large, single dose applications of fertilizer.

The phosphorus and potassium fertilizers provided yield increases in the two years following application. Unusually dry conditions in parts of the growing season in 1989 and 1990 resulted in not only lower than average forage yields, but also provided excellent conditions for grasshoppers. These factors no doubt greatly reduced yields of the Lidster and Nicklen pastures in the first two years of the project and illustrate some of the risks that must be considered when managing fertilizer inputs for grazing land.

The Black Pasture Site provided relatively good returns over the two years that yields were measured. This site received only modest fertilizer rates and was not subjected to grasshopper infestations. The best returns were for the lowest rates of nitrogen fertilizer. No phosphorus or potassium fertilizers were applied to this site.

Application of fertilizers at the rates used in this project did not result in measurable differences in the quality of the forage as determined by feed test analyses. The fertilizer applications in this project must therefore be justified on yield increases alone.

In summary, the Pasture Fertilization Project has demonstrated that:

- application of fertilizer to pasture grass increases total forage yields

- phosphorus and potassium fertilizers will provide yield increases for several years after application

- application of fertilizers does not have significant effects on pasture forage quality

- knifing fertilizer into established pastures does not provide as large an initial response as broadcast applications due to the concentration of the fertilizer in the band and the damage done to the sod at the point of injection

- uncontrollable climatic and insect risks make large single dose applications of fertilizer on established pastures a risky practice

- annual applications of modest amounts of nitrogen fertilizers provide the highest potential for economic yield increases

- the increase in the carrying capacity of pastures as a result of fertilizer use, provides a potential for significant economic gains

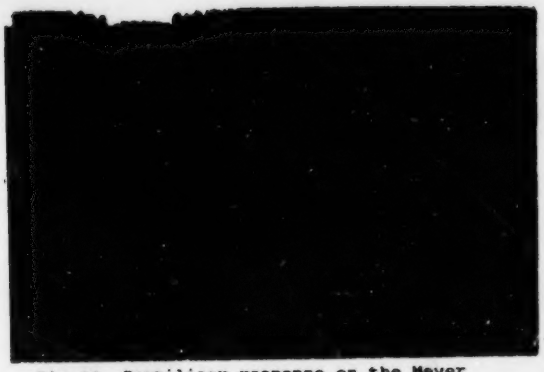

Fig 14. Fertilizer response on the Meyer Alfalfa Site, July. 1989 . Fertilized plot on left, Check on the right

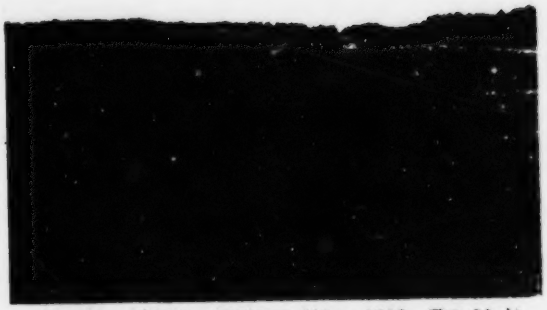

Fig 15. Lidster Pasture Site, 1990. The 90 lb N plot is on the left and the Check plot is on the right

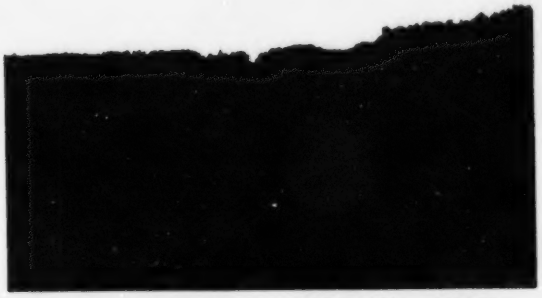

Fig 16. Lidster Pasture Site, 1991, showing no visual response to the residual fertilizer

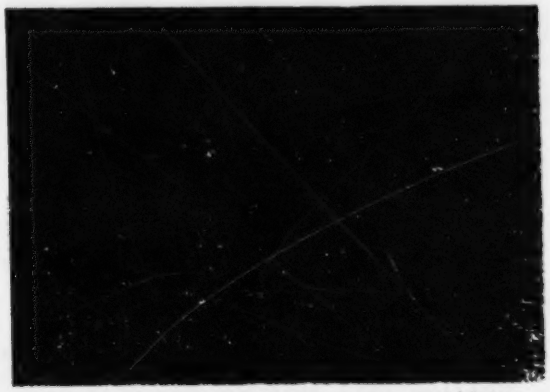

Fig 17. Severe grasshopper damage on Lidster Pasture Site, Aug, 1989

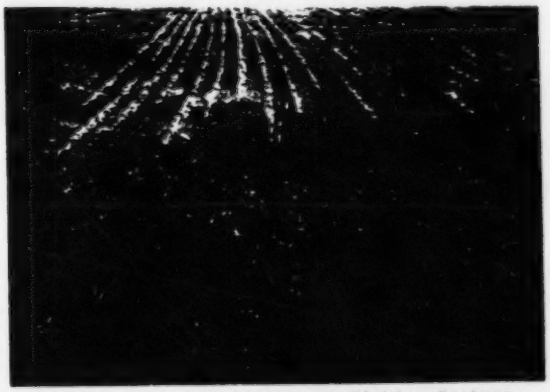

Fig 18. Banded fertilizer on Nicklen Pasture Site, May 16, 1989. Note damage caused by banding

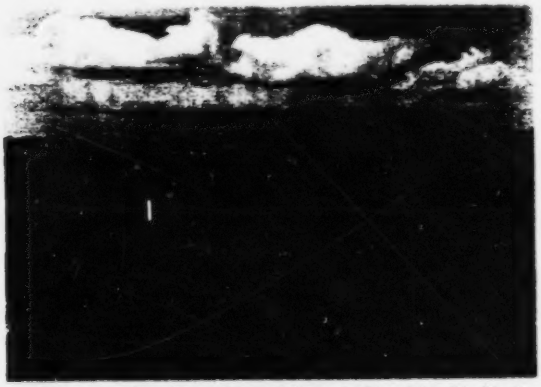

Fig 19. Black Pasture Site, 1991. The 75 lb N plot is on the right and the Check plot is on the left

Fig 20. Riemer Forage Establishment Site, 1990. Oats at 10 lb/ac are on the right, at 68 lb/ac are on the left

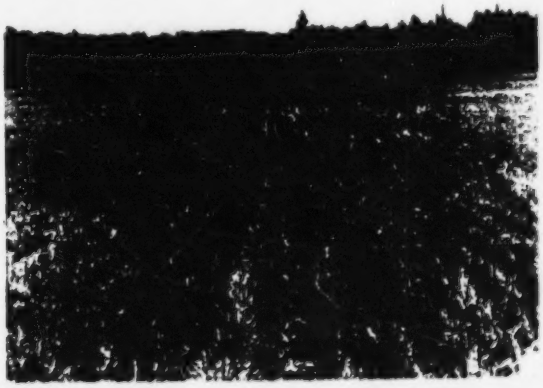

Fig 21. Riemer Forage Establishment Site, 1991. 10 lb/ac oat plot on left, 34 lb/ac oat plot on right

4.0 SOD SEEDING

4.1 Introduction

The Sod-Seeding project was designed to demonstrate the effectiveness of rejuvenating pastures by direct seeding into pasture sod without any pre-seeding cultivation. The project also allowed the evaluation of seeding equipment.

The sod-seeding activities were initiated in 1989 under Project D89-05-0542 and continued in 1990 and 1991 under Project D90-CF-0755.

4.2 Project Design

A total of 10 sod-seeding sites were established in 1989 and 1990. These sites were located in the White Fox, Nipawin, Carrot River, and Smokey Burn areas (Table 11). The sites provided a range of soil textures from clay to sand.

Table 11. Co-operators and site locations for the Sod Seeding project

B. Bartel (1989)	SE 2-51-11-W2
R. Evans (1989)	SW 34-51-14-W2
A. Ginter (1989)	SW 8-49-11-W2
A. Ginter (1990)	SW 8-49-11-W2
G.A. Lidster (1989)	SE 17-53-13-W2
G.A. Lidster (1990)	SE 17-53-13-W2
D. Maier (1989)	SE 15-50-12-W2
F. Reimer (1989)	SW 22-51- 8-W2
G. Trites (1990)	SW 6-51-08-W2
J. Woodward (1990)	SW 1-52-13-W2

At each site the plots were treated with 2 litres/acre of Roundup in early June. A John Deere 750 All-Till drill was used to seed grass mixtures directly into the unworked sod.

plots in either 1989 or 1990. It appears as though not all of the vegetation was at the optimum stage for control at the time of spraying. On the Reimer site in 1989, there was a significant population of red clover in the stand. Removal of the competition of the grasses allowed the clovers to thrive to the extent that a quite acceptable stand of clover was present by late summer. Broadleaf weeds were also released on some sites by the removal of the grasses (Figure 22). Canada thistle, sow thistle, dandelion, and plantain were the most common weeds encountered.

4.3.2 Seeding Operation

The John Deere 750 All-Till Drill (Figure 24) provided good sod penetration, depth control, and seed placement. The single disk opener uniformly penetrated the sod and placed the seed at the desired depth. The packing and covering wheels behind the opener provided adequate packing. Even the dry, hard clay soils at the Trite site did not present a problem for the drill. However, the clay soils did cause problems when the soil was wet. The clay tended to stick to the wide gauge wheels and lift the disks out of the ground.

Soil disturbance was minimal with the drill (Figure 25). Even on the very sandy sites, disturbance was not sufficient to increase the wind erosion hazard significantly.

4.3.3 Stand Establishment

The plots seeded in June of 1989 had good germination and emergence. Unfortunately, on all but two of the 1989 sites, a heavy infestation of grasshoppers completely destroyed the newly established stands.

The Evans and Ginter sites were not damaged by grasshoppers and formed good stands of the hay mixtures. The Evans site on very sandy soil, has produced a very good stand, despite being heavily grazed during the establishment year. The Ginter site also produced a very good stand. However, a heavy infestation of Canada thistle necessitated spraying, which removed the trefoil from the stand. The brome and crested wheatgrass have formed an excellent stand after two years (Figure 28).

In 1990, seeding was delayed until August in an effort to avoid damage by grasshoppers. It was hoped that after killing the green vegetation with Roundup in

June that the grasshoppers on the plots would either perish or migrate off the plots.

Seeding in August did avoid most of the grasshopper damage. However, extremely dry soil conditions at that time of the year reduced germination, emergence, and winter survival on some of the plots.

The Trite site on clay soils was too dry to allow stand establishment. Only a small percentage of the seeds germinated. Those that did could not root effectively into the dry soil and perished during the winter. This site demonstrated the need to seed at a more optimum time in terms of soil moisture on the heavy textured soils.

The meadow brome was successfully established at the Ginter site in 1990 (Figure 27). The creeping foxtail has not established as well, however, due to its strong creeping characteristics, it may eventually produce an adequate pasture. The 1990 Ginter site developed a significant population of Canada thistle. Spraying to control the thistle also removed the trefoil from the stand.

The Woodward site and the 1990 Lidster site demonstrated the ability of meadow brome to establish on very arid, low fertility sites. The meadow brome germinated quickly and has rapid growth characteristics that allowed grazing of the Woodward plot in July of 1991 and harvesting of hay from the Lidster plot in mid-summer of 1991 (Figures 23 & 26).

The Russian wild rye planted on plots adjacent to the brome plots on the Lidster and Woodward sites did not perform nearly as well. In fact, over most of the plots, the Russian wild rye was a complete failure.

4.4 Summary

The sod-seeding project has demonstrated several aspects of the "zero-till" approach to pasture rejuvenation:

- one application of Roundup in June at 2 litres/acre does not provide adequate control of the old pasture stand. This is particularly true if there is a significant amount of smooth brome in the stand.

- grasshopper populations must be considered in a sod-seeding operation. Relatively low hopper populations

can be devastating when the only green foliage is the newly emerging seedlings.

- the John Deere Model 750 All-till drill did an excellent job of sod penetration and seed placement under all soil conditions encountered in the project.

- on sandy sites where the sod is very thin, almost any disk drill would be capable of adequate penetration. On sites with a well developed sod, establishment of the new stand can be adversely affected by having to seed relatively deeply to put the seed in mineral soil.

- removal of the old pasture stand can encourage the growth of broadleaf weeds. The inclusion of legumes in the new stand restricts the use of herbicides to control the weeds.

- Meadow Brome is very easy to establish. It germinates and grows quickly to produce a significant amount of forage in the establishment year. It out-performed Russian wild rye in this project, even on very sandy, dry, low fertility sites.

4.5 Recommendations

The results of the Sod Seeding Demonstration Project suggest a number of tentative recommendations for "zero-till" pasture rejuvenation:

1. Split applications of Roundup are required for adequate control of the existing pasture stands, particularly if smooth brome is a significant part of the stand. Two possible times of the herbicide could be tried:

   - one spring application in June with a second in late summer, followed by "dormancy seeding" in the fall

   - one summer application of herbicide with the second the following spring, and seeding done in late June

2. Sod-seeding may not be an option under conditions of thick, dense sod. In order to obtain good seed-soil contact, the seed may have to be placed too deeply for good emergence.

3. Control of broadleaf weeds may require that the legume component of the stand be established after the

weeds are controlled, but before the grasses become too competitive.

4. Meadow brome should be considered as a species for sod-seeding programs. It germinates quickly and establishes easily. Under the conditions of this project it has out-performed Russian wild rye, even on very dry sites.

Fig 22. Lidster 1990 Sod Seeding Site. Meadow brome on left, Russian wild rye on right. Photo, May 16/1991

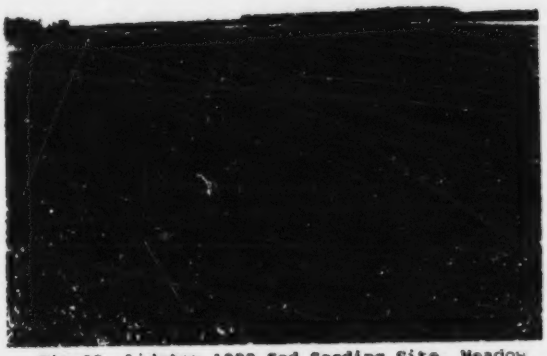

Fig 23. Lidster 1990 Sod Seeding Site. Meadow brome on left, Russian wild rye on right. Plots were clipped in July, photo Aug 10/1991

Fig 24. John Deere All-Till Drill at the Woodward Sod Seeding Site, Aug, 1990

Fig 25. Woodward Sod Seeding Site, Aug, 1990

Fig 26. Woodward Sod Seeding Site, July 3, 1991. Meadow brome plot on right, original pasture stand on left

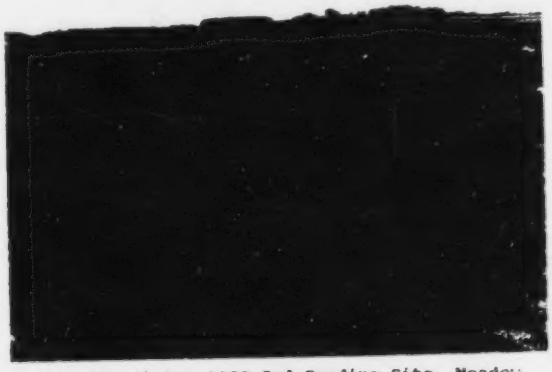

Fig 27. Ginter 1990 Sod Seeding Site. Meadow brome on left, creeping foxtail on right. Photo July 22, 1991, after grazing

Fig 28. Ginter 1989 Sod Seeding Site in May, 1991

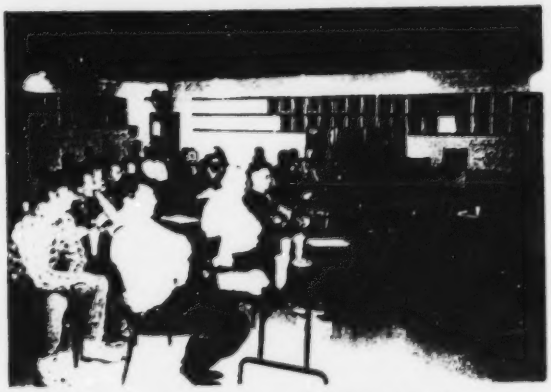

Fig 29. Silage seminar sponsored by the Northeast Grassland and Forage Association and the Agriculture Development Fund, Mar/91

5.0 Forage Establishment

5.1 Introduction

Forages are usually established by underseeding them in an annual crop. This has the advantage of providing revenue from the field in the year that the forage is established. As well, the cover crop provides competition which helps control weeds.

This project was designed to demonstrate the effect of varying the seeding rate of the cover crop on the resulting stand of forage.

5.2 Project Design

Three sites were established in 1990 to demonstrate the effect of cover crop density on forage establishment and the yield of forage in subsequent years. The sites are located in the Love, White Fox, and Carrot River areas (Table 12).

Forage yield measurements were taken at the Riemer site in 1991 to determine if the seeding rates of the cover crop had significant effects on forage yields. Three "growth cages" were located in each of the three treatments. Yield measurements were collected from the cages four times during the growing season.

Table 12. Co-operators and site locations for the Forage Establishment Demonstration

R. Paschke	SE 32-52-15-W2
R. Nicklen	NW 7-50-10-W2
C. Riemer	NW 4-52-14-W2

5.2.1 Paschke Site

The forage mixture established on the Paschke site includes alfalfa, crested wheat grass, brome grass and intermediate wheat grass. The forage was seeded under a barley cover crop. The plot area includes three

different seeding rates for the barley cover crop. These rates were 0.5, 1.0, and 1.5 bushels/acre.

5.2.2 Nicklen Site

The forages on the Nicklen site were seeded under flax as the cover crop. The seeding rates for the flax in the plot area were 0, 15, and 30 pounds/acre.

5.2.3 Riemer Site

The forage on the Riemer site was seeded under oats as the cover crop. The seeding rates for the oats in the test area were 10, 34, and 68 pounds/acre. The forage used was meadow brome.

5.3 Observations

There were no visible differences in forage establishment on the Paschke site.

The Nicklen site had to be re-seeded due to severe grasshopper damage. The late seeding date did not allow the use of a cover crop at the second seeding.

The Riemer site provided some interesting responses. The most obvious were the effects of the different seeding rates of the oats on their stand and maturity. The 10 pound seeding rate produced plants about 45 inches tall with up to 13 tillers. The 34 and 68 pound seeding rates produced stands about 40 and 35 inches tall, respectively. The maturity of the oats was greatly delayed by the light seeding rate (Figure 20).

Forage yields of the oats taken on August 10, 1990 indicate that the total dry matter yield was very similar for all seeding rates. The 10 pound seeding rate yielded about 2.6 tons/acre; the 34 pound and 68 pound seeding rates each yielded about 2.4 tons/acre.

The seeding rate of the oat cover crop also had a visible effect on the grass seedlings. There was a noticeably higher population of grass seedlings under the 10 pound oat seeding rate than under either the 34 or 68 pound rates. As well, in the establishment year the seedlings grew up to 24 inches in height under the light cover crop compared to only 8 to 10 inches under the denser oat stands.

Yield measurements during 1991 indicate that the total forage production of the meadow brome was not greatly affected by the different seeding rates of the cover crop (Figure 30). However, early season growth was much higher on the plot with the lightest cover crop (Figures 21 & 31). As the season progressed, the yield differences among the plots became quite small. In fact, in the last two harvests there may have been a slightly higher forage yield from the plots with the heaviest cover crop (Table 13).

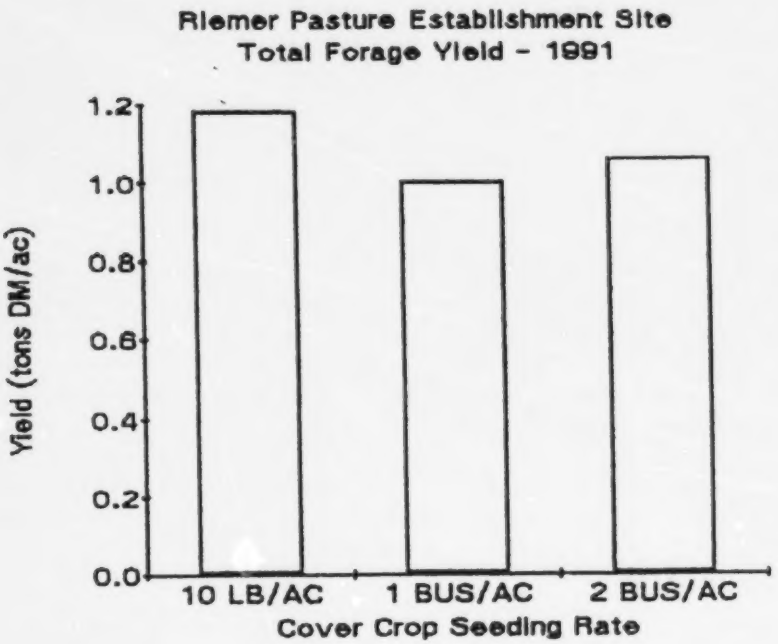

Figure 30. Total forage yields on the Riemer Forage Establishment Site as affected by cover crop seeding rate

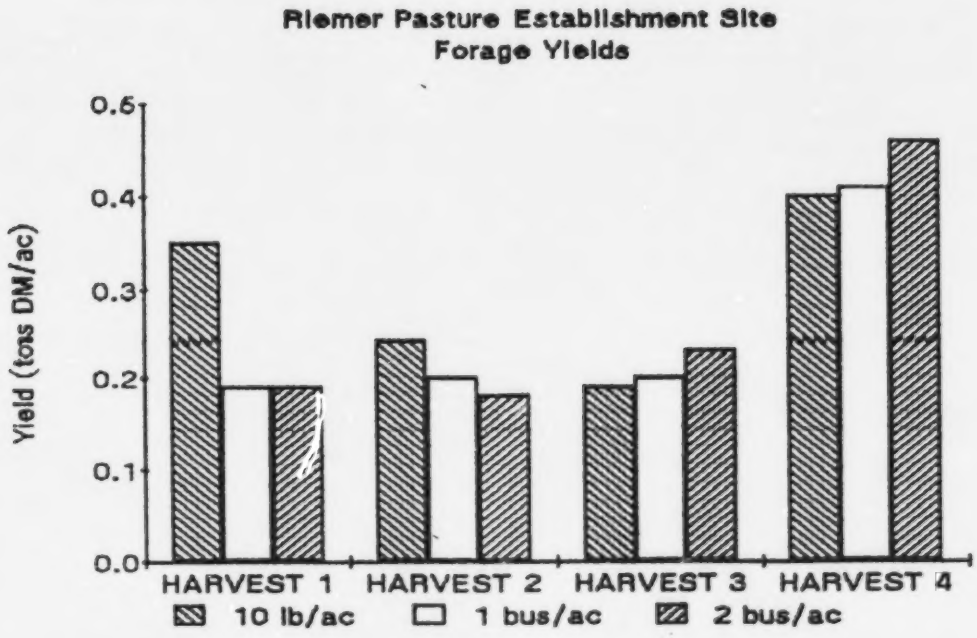

Figure 31. Forage yields for each harvest in 1991 as affected by cover crop density at the Riemer Site

Table 13. Effect of cover crop seeding rate on forage yield of meadow brome in 1991.

SITE	HARVEST	YIELD (TONS DM/ACRE) 10 LB/AC	1 BUS/AC	2 BUS/AC
RIEMER	MAY 28/91	0.35	0.19	0.19
	JUNE 19/91	0.24	0.20	0.18
	JULY 9/91	0.19	0.20	0.23
	SEPT 12/91	0.40	0.41	0.46
	TOTALS	1.18	1.00	1.06

5.4 Summary

The Pasture Establishment Project demonstrated several aspects of cover crop management:

1. Thin cover crops enhance seedling growth in the establishment year

2. Meadow Brome established under thin cover crop produced more forage the next spring than when established under heavy crop crops

3. By mid-summer of the first year after establishment, the cover crop density no longer affected the forage yield of the meadow brome

4. The forage yield of the oats was not significantly affected by seeding rate

APPENDIX

Appendix 1. Fertility of Alfalfa Project soil test levels and fertilizer recommendations for samples taken in the spring of 1989 (Field) and for each treatment taken in the fall of 1989.

											Recommended Fertilizer			
PLOT	TRTMT	N	P	K	S	Cu	Fe	Zn	Mn	B	P2O5	K2O	S	Cu
BRITTON	FIELD	10	11	100	29	0.72	42.8	1.36	11.40	2.64	50	110	15	5
	1	18	15	130	79+	0.68	65.6	1.40	5.56	2.24	50	90	--	5
	2	16	14	140	83+	2.28	52.0	1.32	8.36	2.80	50	90	--	--
	CHECK	11	10	100	61	0.68	43.2	1.04	5.32	1.80	75	110	--	5
GINTER	FIELD	13	15	200	72+	3.40	234.4	3.00	15.92	3.24	50	50	--	--
	1	9	10	130	71	2.16	171.2	3.52	3.64	1.68	75	90	--	--
	2	9	10	200	62	2.76	181.6	2.80	3.00	1.68	75	50	--	--
	CHECK	6	7	150	39	1.48	134.0	1.64	2.72	1.72	75	90	10	--
JOHANSEN	FIELD	8	19	260	96+	4.24	136.0	17.28	31.40	5.60	25	--	--	--
	1	10	63	600	89+	3.48	179.6	21.48	15.12	4.00	--	--	--	--
	2	8	35	390	96+	7.56	120.4	19.68	14.96	2.80	--	--	--	--
	CHECK	9	18	280	84+	2.68	92.4	11.40	12.96	3.40	25	--	--	--
MEYER	FIELD	14	11	170	41	1.48	146.0	4.16	17.36	2.88	50	60	10	--
	1	10	8	220	91+	1.00	139.6	2.40	7.52	1.28	75	--	--	--
	2	10	8	220	85+	4.16	124.4	2.88	5.68	2.16	75	--	--	--
	CHECK	13	8	200	79+	1.08	78.0	2.88	5.92	3.16	75	50	--	--
MUNRO	FIELD	14	17	230	61+	0.80	98.4	1.56	14.60	1.84	25	--	--	5
	1	8	16	220	56	0.84	71.6	2.04	8.20	1.20	25	--	--	--
	2	12	28	320	57	2.32	97.2	2.72	10.96	0.84	--	--	--	--
	CHECK	9	14	170	48	0.88	65.2	1.84	9.80	1.04	50	60	--	--
REAVIE	FIELD	14	24	200	96+	5.16	207.2	10.32	17.04	6.36	--	50	--	--
	1	8	27	230	96+	3.56	143.6	8.32	5.92	3.12	--	--	--	--
	2	9	25	330	96+	5.40	192.4	8.80	10.08	3.28	--	--	--	--
	CHECK	12	28	340	96+	3.28	225.2	22.00	10.12	3.48	--	--	--	--
WOOD	FIELD	13	30	220	87+	2.60	291.6	16.32	45.60	3.00	--	--	--	--
	1	5	32	290	96+	4.16	236.8	9.80	19.88	1.40	--	--	--	--
	2	10	27	330	96+	1.80	314.0	12.44	26.04	1.68	--	--	--	--
	CHECK	8	25	230	92+	--	--	--	--	--	--	--	--	--

Appendix 2. Fertility of Alfalfa Project soil test levels and fertilizer recommendations for samples taken in the fall of 1990.

PLOT	TRTMT	N	P	K	S	Cu	Fe	Zn	Mn	B	Recommended Fertilizer P2O5	K2O	S	Cu
BRITTON	1	17	14	140	54	1.60	210.4	3.68	3.92		50	90	0	0
	2	22	13	160	47	3.16	210.0	2.68	3.64		50	60	0	0
	CHECK	18	6	110	35	2.68	205.6	2.60	4.88		75	110	15	0
GINTER	1	13	7	160	85+	2.36	347.6	18.36	35.64		75	60	0	0
	2	11	11	190	52	4.28	408.0	22.40	31.60		50	50	0	0
	CHECK	14	8	150	53	2.00	432.0	19.44	37.32		75	90	0	0
KEYER	1	20	8	220	57	4.24	287.2	11.00	9.16		75	0	0	0
	2	25	11	240	87+	10.52	283.6	17.92	9.16		50	0	0	0
	CHECK	22	8	180	58	3.12	344.8	21.64	11.16		75	60	0	0
MUNRO	1	10	11	210	42	1.04	168.8	2.48	7.64		50	50	10	0
	2	12	26	340	51	4.84	151.6	4.16	7.20		0	0	0	0
	CHECK	15	9	240	40	1.24	204.8	2.56	6.04		75	0	10	0
REAVIE	1	30	22	200	96+	0.80	14.8	0.96	5.72		0	50	0	5
	2	26	25	310	96+	0.72	33.9	1.24	9.16		0	0	0	5
	CHECK	32	37	310	96+	0.72	36.6	4.16	5.80		0	0	0	5
WOOD	1	5	28	320	96+	0.72	91.6	1.92	12.36		0	0	0	5
	2	9	32	300	91+	2.48	130.8	1.88	15.92		0	0	0	0
	CHECK	8	18	310	90+	0.96	96.4	1.68	12.96		25	0	0	0

Appendix 3. 1989 feed analyses of the second harvest of the Fertility of Alfalfa plots. Results are the average of 3 replicates.

PLOT	TRTMT	PROTEIN (%)	CALCIUM (%)	PHOSPHORUS (%)	ENERGY % TDN	ADF (%)	COPPER ppm
BRITTON	1	24.40	1.64	0.28	59-61	37.79	6.47
	2	23.95	1.61	0.28	60-62	36.21	6.37
	CHECK	24.76	1.94	0.24	62-65	30.99	--
GINTER	1	20.15	1.75	0.18	61-63	34.27	8.67
	2	20.56	1.79	0.17	61-63	32.95	9.01
	CHECK	20.42	1.82	0.15	62-65	31.77	--
JOHANSEN	1	23.83	2.17	0.26	65-68	28.37	10.9
	2	23.50	2.14	0.25	66-68	28.05	11.58
	CHECK	23.12	2.13	0.22	66-69	26.84	--
MEYER	1	19.84	1.90	0.22	63-65	29.51	7.4
	2	20.49	1.85	0.22	64-66	30.01	8.78
	CHECK	20.66	1.96	0.16	66-68	26.71	--
MUNRO	1	22.45	2.30	0.20	62-64	32.36	9.18
	2	22.20	2.01	0.23	60-62	35.1	8.84
	CHECK	23.01	2.00	0.23	61-63	32.79	--
REAVIE	1	24.46	1.91	0.25	67-70	25.2	10.64
	2	23.60	1.78	0.25	67-69	26.53	10.99
	CHECK	24.15	1.86	0.23	68-70	24.46	--
WOOD	1	23.24	2.05	0.22	64-66	29.21	9.5
	2	24.73	2.15	0.22	67-69	26.12	9.62
	CHECK	24.76	1.85	0.22	64-67	28.11	--

Appendix 4. 1990 feed analyses of the second harvest of the Fertility of Alfalfa plots. Results are the average of 3 replicates.

PLOT	TRTMT	PROTEIN (%)	CALCIUM (%)	PHOSPHORUS (%)	ENERGY % TDN	ADF (%)	COPPER ppm
BRITTON	1	20.64	2.35	0.15	64-66	30.68	7.96
	2	21.46	2.34	0.16	62-65	31.86	10.08
	CHECK	22.13	2.53	0.19	64-66	30.73	9.78
GINTER	1	19.83	2.66	0.15	64-67	29.54	9.11
	2	19.12	2.63	0.13	64-66	29.76	8.83
	CHECK	18.71	2.78	0.14	66-68	27.72	8.27
MUNRO	1	22.25	2.30	0.21	64-67	29.66	7.7
	2	22.03	2.46	0.20	63-66	30.89	9.68
	CHECK	22.47	2.45	0.24	63-65	31.53	7.71
WOOD	1	24.63	2.54	0.22	68-70	24.77	10.59
	2	22.74	2.60	0.19	68-70	25.33	10.88
	CHECK	21.94	2.14	0.18	68-70	25.41	8.98

Appendix 5. 1989 plant tissue analyses of the second harvest of the Fertility of Alfalfa plots.

		percent						parts per million				
PLOT	TRTMT	N	P	K	S	Ca	Mg	Cu	Fe	Mn	Zn	B
BRITTON	1	5.06	0.31	1.64	0.35	1.82	0.43	9	139	48	28	41
	2	4.56	0.31	1.80	0.34	1.79	0.49	10	126	50	27	39
	CHECK	4.41	0.28	1.29	0.32	2.13	0.53	12	123	54	29	45
GINTER	1	4.24	0.22	1.91	0.30	2.16	0.34	9	133	19	23	24
	2	4.41	0.25	2.16	0.37	1.89	0.28	11	145	27	27	43
	CHECK	3.34	0.17	1.66	0.24	2.43	0.46	10	134	32	29	38
JOHANSEN	1	4.24	0.28	1.75	0.34	2.02	0.25	10	133	25	47	60
	2	4.28	0.31	2.15	0.48	2.22	0.23	13	176	22	41	50
	CHECK	4.41	0.21	1.82	0.40	2.23	0.26	12	190	39	48	64
MEYER	1	4.22	0.19	1.62	0.41	2.12	0.43	8	154	30	28	63
	2	3.57	0.18	1.64	0.38	2.33	0.43	10	165	50	29	72
	CHECK	3.57	0.15	1.59	0.35	2.30	0.39	9	106	40	34	82
MUMBO	1	4.14	0.25	2.03	0.41	2.90	0.26	11	138	33	29	29
	2	2.82	0.26	2.23	0.36	2.44	0.22	10	133	22	29	23
	CHECK	4.58	0.30	2.35	0.33	2.00	0.21	9	169	28	34	25
REAVIE	1	4.51	0.28	1.78	0.42	1.92	0.30	13	156	24	39	57
	2	4.18	0.26	1.79	0.41	1.84	0.34	13	318	33	55	62
	CHECK	4.25	0.26	1.87	0.39	1.77	0.34	13	317	30	51	58
WOOD	1	4.58	0.26	1.85	0.40	2.31	0.29	12	190	26	28	60
	2	4.64	0.26	2.17	0.35	1.79	0.26	11	160	22	31	52
	CHECK	4.23	0.24	2.09	0.35	1.52	0.33	10	137	20	29	58

Appendix 6. 1990 plant tissue analyses of the second harvest of the Fertility of Alfalfa plots.

		percent						parts per million				
PLOT	TRTMT	N	P	K	S	Ca	Mg	Cu	Fe	Mn	Zn	B
BRITTON	1	3.78	0.16	1.21	0.31	3.40	0.51	9	141	37	20	62
	2	4.39	0.25	1.42	0.38	3.31	0.64	12	155	43	29	67
	CHECK	5.05	0.34	1.69	0.40	3.08	0.48	11	171	34	35	65
GINTER	1	3.80	0.22	1.78	0.30	2.70	0.37	8	103	39	22	50
	2	3.23	0.14	1.51	0.30	3.66	0.59	10	132	54	27	53
	CHECK	3.03	0.12	1.29	0.32	3.88	0.80	10	140	56	34	67
MUNRO	1	4.21	0.25	1.85	0.34	3.28	0.40	9	495	120	35	42
	2	4.57	0.30	2.35	0.39	2.89	0.29	9	214	61	46	43
	CHECK	5.12	0.39	2.28	0.40	3.19	0.38	7	171	46	37	49
WOOD	1	4.59	0.28	2.33	0.43	2.67	0.39	13	186	37	35	71
	2	4.39	0.24	2.14	0.46	3.51	0.42	14	186	35	44	81
	CHECK	4.51	0.24	2.22	0.43	2.89	0.41	14	160	33	41	87

Appendix 7. Pasture Fertilization Project soil test levels and fertilizer recommendations for samples taken in the spring of 1989 (Field) and for each plot taken in the fall of 1989.

											Recommended Fertilizer			
PLOT	TRTMT	N	P	K	S	Cu	Fe	Zn	Mn	B	N	P2O5	K2O	S
LIDSTEN	FIELD	5	25	100	18	0.72	158.8	2.36	33.64	3.36	95	--	90	15
	1	5	15	100	18						95	50	90	15
	2	5	13	80	29						95	50	110	--
	3	5	15	50	58+						95	50	140	--
	CHECK	5	17	60	23						95	25	140	10
TREW	FIELD	122	22	260	24+	4.68	444.0	39.65	38.76	4.24	--	20	--	--
	1	36	35	470	96+						70	15	--	--
	2	23	16	150	93+						85	25	60	--
	3	23	35	400	96+						85	15	--	--
	CHECK	13	25	300	96+						95	20	--	--
NICKLEN	BANDED	5	10	220	86+						95	75	--	--
	1	5	15	350	84						95	50	--	--
	2	5	20	300	89+						95	25	--	--
	3	7	25	350	57						90	--	--	--
	CHECK	6	21	280	60+						90	--	--	--

Appendix 8. 1990 soil test levels and fertilizer recommendations for Pasture Fertilization plots.

PLOT	TRTMT	N	P	K	S	Cu	Fe	Zn	Mn	B	Recommended Fertilizer N	P2O5	K2O	S
LIDSTER	1	6	7	70	30						90	75	110	0
	2	9	11	90	35						90	50	110	0
	3	9	17	110	63+						90	25	90	0
	CHECK	9	11	70	24						90	50	110	10
BLACK	1	17	22	350	85+						80	0	0	0
	2	15	18	460	65						85	25	0	0
	3	33	10	260	52						65	75	0	0
	CHECK	17	14	300	57						80	50	0	0
NICKLEN	BANDED	9	18	390	96+						90	25	0	0
	1	7	13	410	53						90	50	0	0
	2	5	20	370	96+						95	25	0	0
	3	12	12	320	77						85	50	0	0
	CHECK	5	19	440	60+						95	25	0	0

Appendix 9. 1989 feed analyses of the second harvest of the Pasture Fertilization plots. Results are the average of 3 replicates.

PLOT	TRTMT	PROTEIN (%)	CALCIUM (%)	PHOSPHORUS (%)	ENERGY % TDN	ADF (%)	NITRATE (%)
LIDSTER	1	10.52	0.39	0.20	52-54	42.41	--
	2	11.03	0.35	0.20	51-53	43.87	--
	3	10.72	0.45	0.2	51-53	44.54	--
	CHECK	12.41	0.50	0.25	53-56	41.8	--
NICKLEN	BANDED	12.13	0.50	0.27	53-56	41.63	--
	CHECK 1	11.07	1.12	0.34	57-59	35.07	--
	1	12.52	0.58	0.34	57-59	38.84	--
	2	9.36	0.44	0.24	54-57	40.28	--
	3	10.77	0.64	0.32	56-58	37.84	--
	CHECK 2	9.81	0.63	0.30	54-57	40.29	--

Appendix 10. 1990 feed analyses of the second harvest of the Pasture Fertilization plots. Results are the average of 3 replicates.

PLOT	TRTMT	PROTEIN (%)	CALCIUM (%)	PHOSPHORUS (%)	ENERGY % TDN	ADF (%)
LIDSTER	1	14.87	0.81	0.17	57-59	37.69
	2	13.34	0.63	0.17	57-59	37.93
	3	15.07	0.84	0.16	58-60	37.19
	CHECK	13.10	0.71	0.22	56-58	39.09
BLACK	1	12.76	0.56	0.22	56-58	39.01
	2	13.07	0.61	0.20	58-60	36.99
	3	14.21	0.56	0.20	59-61	36.17
	CHECK	13.88	0.62	0.21	57-59	37.74
NICKLEN	BAND	10.02	0.84	0.14	56-58	39.24
	CHECK	10.17	0.79	0.34	52-54	41.99
	1	10.99	1.11	0.24	63-66	31.83
	2	9.66	0.56	0.18	57-59	37.58
	3	10.84	0.82	0.29	56-58	39.26

Appendix 11. 1991 feed analyses of the second harvest of the Pasture Fertilization plots.

PLOT	TRTMT	PROTEIN (%)	CALCIUM (%)	PHOSPHORUS (%)	ENERGY % TDN	ADF (%)
LIDSTER	1	15.22	0.66	0.31	56-58	39.53
	2	14.09	0.72	0.26	57-59	38.82
	3	14.72	0.73	0.21	56-58	39.88
	CHECK	14.98	0.77	0.21	57-59	37.80
BLACK	1	11.98	0.59	0.22	58-60	37.24
	2	12.39	0.68	0.20	59-61	35.56
	3	16.84	0.63	0.16	61-63	33.37
	CHECK	12.79	0.73	0.21	59-61	36.24
NICKLEN	BAND	11.90	0.83	0.33	59-61	35.60
	CHECK	11.26	0.76	0.44	60-62	34.03
	1	11.23	0.68	0.36	60-62	34.80
	2	11.11	0.58	0.40	60-62	33.44
	3	13.53	0.99	0.48	61-63	33.18

Appendix 12. Pasture Fertilization yield data for Harvest 1, 1991.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
LIDSTER	1	1	23.3	8.4	14.9	63.95%	252.2	85.5	60.10	719	291.0	0.32
Jun 9/91		2	19.6	7	12.6	64.29%	330.6	84.4	87.93	1052	425.8	0.47
		3	18.4	7.2	11.2	60.87%	306.2	85.5	86.36	1033	418.2	0.46
		4	20.6	7.8	12.8	62.14%	282.0	85	74.59	892	361.2	0.40
		5	16.8	6.5	10.3	61.31%	157.0	84.8	27.93	334	135.3	0.15
						AVERAGE YIELD				806	326	0.36
	2	1	16.9	5.4	11.5	68.05%	225.4	79.8	46.52	556	225.3	0.25
		2	18.3	5.8	12.5	68.31%	365.0	86.5	88.27	1056	427.4	0.47
		3	17.9	6.7	11.2	62.57%	295.8	81	80.40	962	389.3	0.43
		4	21.2	8.5	12.7	59.91%	249.6	78	68.80	823	333.1	0.37
		5	14.2	5.6	8.6	60.56%	277.4	79.1	78.20	935	378.7	0.42
						AVERAGE YIELD				866	351	0.39
	3	1	16.9	6.4	10.5	62.13%	222.2	85	51.96	621	251.6	0.28
		2	23	7.5	15.5	67.39%	306.5	81.1	73.50	879	355.9	0.39
		3	16.5	5.8	10.7	64.85%	298.0	83.9	75.26	900	364.4	0.40
		4	22.2	8	14.2	63.96%	293.0	77.2	77.77	930	376.6	0.42
		5	20.6	7	13.6	66.02%	236.5	78.9	53.55	640	259.3	0.29
						AVERAGE YIELD				794	322	0.35
	CHECK	1	22.5	7.1	15.4	68.44%	318.9	82.7	74.53	891	360.9	0.40
		2	23.7	8.1	15.6	65.82%	278.0	82.2	66.92	800	324.0	0.36
		3	18.7	6.3	12.4	66.31%	295.1	87	70.11	838	339.5	0.37
		4	22	8.3	13.7	62.27%	274.2	85.2	71.30	853	345.3	0.38
		5	30.7	9.8	20.9	68.08%	195.6	83.5	35.78	428	173.3	0.19
						AVERAGE YIELD				762	309	0.34
BLACK	1	1	27.4	8.9	18.5	67.52%	550.0	89.7	149.51	1788	724.0	0.80
JUNE 8/91		2	28.7	8.3	20.4	71.08%	863.0	86.4	224.59	2686	1087.5	1.20
		3	24.1	8.4	15.7	65.15%	452.5	85.3	127.99	1531	619.7	0.68
						AVERAGE YIELD				2002	810.4	0.89
	2	1	22.5	7.8	14.7	65.33%	456.3	91.4	126.50	1513	612.5	0.68
		2	22.8	7.6	15.2	66.67%	742.5	88.2	218.10	2608	1056.1	1.16
		3	21.5	7.2	14.3	66.51%	566.5	89	159.91	1912	774.3	0.85
						AVERAGE YIELD				2011	814.3	0.90
	3	1	20.4	7.4	13	63.73%	421.2	86.5	121.41	1452	587.9	0.65
		2	29.2	9.3	19.9	68.15%	787.8	90.3	222.15	2657	1075.7	1.19
		3	25.2	6.6	18.6	73.81%	712.5	86.7	163.90	1960	793.6	0.87
						AVERAGE YIELD				2023	819.1	0.90
	CHECK	1	30.9	11.7	19.2	62.14%	226.8	88	52.56	629	254.5	0.28
		2	21.4	7.9	13.5	63.08%	293.1	88.6	75.49	903	365.5	0.40
		3	22.9	7.5	14.1	67.25%	357.3	87.5	88.36	1057	427.9	0.47
						AVERAGE YIELD				863	349.3	0.39

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
NICKLEW	BAND	1	13.9	5.6	8.3	59.71%	219.0	83.2	54.71	654	264.9	0.29
JUNE 6/91		2	15.6	5.4	10.2	65.38%	249.1	80.8	58.26	697	282.1	0.31
		3	19.5	6.6	12.9	66.15%	234.0	83.2	51.04	610	247.1	0.27
		4	16.6	5.9	10.7	64.46%	239.6	80	56.73	678	274.7	0.30
						AVERAGE YIELD				660	267.2	0.29
	CHK 1	1	15.8	6.6	9.2	58.23%	182.0	78.5	43.23	517	209.3	0.23
		2	20.5	6.1	14.4	70.24%	140.5	84	16.81	201	81.4	0.09
		3	19.9	7.5	12.4	62.31%	172.3	83.4	33.51	401	162.2	0.18
		4	19.1	7.6	11.5	60.21%	143.5	80.8	24.95	298	120.8	0.13
						AVERAGE YIELD				354	143.4	0.16
	1	1	14	8.1	5.9	42.14%	140.0	83.4	32.75	392	158.6	0.17
		2	19.3	6.6	12.7	65.80%	192.1	81	37.99	454	184.0	0.20
		3	17.4	6.6	10.8	62.07%	165.6	82	31.71	379	153.5	0.17
		4	19.1	6.3	12.8	67.02%	168.0	81	28.70	343	139.0	0.15
						AVERAGE YIELD				392	158.8	0.18
	2	1	18.9	8.6	10.3	54.50%	278.0	78.5	90.78	1086	439.6	0.48
		2	25.9	10.3	15.6	60.23%	174.0	80	37.38	447	181.0	0.20
		3	18.9	7.3	11.6	61.38%	196.0	85.5	42.68	510	206.7	0.23
		4	21.9	7.5	14.4	65.75%	239.6	83.1	53.60	641	259.5	0.29
						AVERAGE YIELD				671	271.7	0.30
	3	1	24.3	9.6	14.7	60.49%	261.0	85.5	69.33	829	335.7	0.37
		2	22	7.1	14.9	67.73%	230.0	82.5	47.60	569	230.5	0.25
		3	20.2	6.9	13.3	65.84%	254.4	85.2	57.80	691	279.9	0.31
		4	18.9	5.4	13.5	71.43%	213.5	82.7	37.37	447	181.0	0.20
						AVERAGE YIELD				634	256.8	0.28

Appendix 13. Pasture Fertilization yield data for Harvest 2, 1991.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
LIDSTER	1	1	23.6	8.8	14.8	62.71%	205.2	84.8	44.89	537	217.4	0.24
JULY 23/91		2	20	8.9	11.1	55.50%	131.5	85.5	20.47	245	99.1	0.11
		3	17.9	7	10.9	60.89%	170.6	87.5	32.50	389	157.4	0.17
		4	22	9.6	12.4	56.36%	119.0	84.7	14.97	179	72.5	0.08
		5	17.8	8.6	9.2	51.69%	108.5	85.5	11.11	133	53.8	0.06
						AVERAGE YIELD				296	120	0.13
	2	1	16.1	5.9	10.2	63.35%	181.0	81.7	36.39	435	176.2	0.19
		2	22.7	8.3	14.4	63.44%	271.4	87.5	67.24	804	325.6	0.36
		3	24.3	8	16.3	67.08%	225.1	84	46.45	556	224.9	0.25
		4	24.7	8.6	16.1	65.18%	245.5	78.7	58.08	695	281.2	0.31
		5	18.8	7.1	11.7	62.23%	230.2	80.3	56.61	677	274.1	0.30
						AVERAGE YIELD				633	256	0.28
	3	1	24.7	9.8	14.9	60.32%	173.8	86.4	34.68	415	167.9	0.19
		2	19.8	8.1	11.7	59.09%	204.3	82.3	49.91	597	241.7	0.27
		3	19.9	7.2	12.7	63.82%	298.2	84	77.50	927	375.3	0.41
		4	17	6.8	10.2	60.00%	175.0	80.4	37.84	453	183.2	0.20
		5	21.2	8.4	12.8	60.38%	240.4	80	63.55	760	307.7	0.34
						AVERAGE YIELD				630	255	0.28
	CHECK	1	28.3	11.8	16.5	58.30%	135.9	86.9	20.43	244	98.9	0.11
		2	12.1	4.8	7.3	60.33%	175.1	84.8	35.82	428	173.5	0.19
		3	27.4	9.6	17.8	64.96%	252.7	90.9	56.69	678	274.5	0.30
		4	21.1	8	13.1	62.09%	166.3	88.1	29.65	355	143.6	0.16
		5	22.1	9.3	12.8	57.92%	145.5	83.5	26.09	312	126.3	0.14
						AVERAGE YIELD				403	163	0.18
BLACK	1	1	25.9	8.9	17	65.64%	267.5	87.7	61.78	739	299.2	0.33
JULY 22/91		2	23.8	7.4	16.4	68.91%	623.4	90	165.85	1984	803.0	0.89
		3	29.9	10.6	19.3	64.55%	416.3	85	117.45	1405	568.7	0.63
						AVERAGE YIELD				1376	557	0.61
	2	1	21.7	7.1	14.6	67.28%	371.5	88.9	92.46	1106	447.7	0.49
		2	22	8.2	13.8	62.73%	528.6	85.8	165.04	1974	799.2	0.88
		3	26	10	16	61.54%	510.0	83.3	164.12	1963	794.7	0.88
						AVERAGE YIELD				1681	681	0.75
	3	1	26.5	9.3	17.2	64.91%	578.6	84.1	173.54	2076	840.3	0.93
		2	23.8	7.7	16.1	67.65%	487.2	88.7	128.93	1542	624.3	0.69
		3	22.5	7.3	15.2	67.56%	576.3	84.2	159.66	1910	773.1	0.85
						AVERAGE YIELD				1842	746	0.82
	CHECK	1	22.1	7.6	14.5	65.61%	259.8	89.5	58.56	700	283.6	0.31
		2	26.8	9.2	17.6	65.67%	384.6	89.3	101.37	1212	490.9	0.54
		3	26	7.6	14.1	70.77%	290.5	86.1	59.75	715	289.3	0.32
						AVERAGE YIELD				876	355	0.39

Appendix 13. cont'd.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
NICKLEN	BAND	1	16.2	6.2	10	61.73%	242.9	82.4	61.43	735	297.4	0.33
JULY 22/91		2	30.7	11.9	18.8	61.24%	211.0	80.2	50.70	606	245.5	0.27
		3	22.7	7.6	15.1	66.52%	188.0	83	35.15	420	170.2	0.19
		4	23.3	8	15.3	65.67%	139.3	81.1	19.98	239	96.8	0.11
						AVERAGE YIELD				500	202.5	0.22
	CHK 1	1	22.6	8.3	14.3	63.27%	209.6	77.8	48.40	579	234.4	0.26
		2	23.3	8.7	14.6	62.66%	112.0	82.9	10.87	130	52.6	0.06
		3	21	8.5	12.5	59.52%	162.5	83	32.18	385	155.8	0.17
		4	1	1	0	0.00%	1.0	1	0.00	0	0.0	0.00
						AVERAGE YIELD				273	110.7	0.12
	1	1	14.7	6	8.7	59.18%	175.2	83.6	37.39	447	181.0	0.20
		2	22	6.2	15.8	71.82%	215.4	80.6	37.99	454	183.9	0.20
		3	19.8	8.5	11.3	57.07%	141.8	79.8	26.62	318	128.9	0.14
		4	24.9	9.2	15.7	63.05%	121.1	79	15.56	186	75.3	0.08
						AVERAGE YIELD				351	142.3	0.16
	2	1	19.6	8.5	11.1	56.63%	225.0	77.4	64.01	766	309.9	0.34
		2	26	10.5	15.5	59.62%	179.0	78.8	40.47	484	195.9	0.22
		3	27.1	11.1	16	59.04%	159.4	84.4	30.72	367	148.7	0.16
		4	26.9	9.4	17.5	65.06%	174.9	83.6	31.90	382	154.5	0.17
						AVERAGE YIELD				500	202.3	0.22
	3	1	30.6	11.3	19.3	63.07%	305.4	83.4	81.98	980	397.0	0.44
		2	24.7	6.9	17.8	72.06%	241.0	83.5	44.00	526	213.0	0.23
		3	22.3	7.1	15.2	68.16%	271.7	88.8	58.23	696	282.0	0.31
		4	23.7	7.5	16.2	68.35%	228.7	81	46.74	559	226.3	0.25
						AVERAGE YIELD				691	279.6	0.31

Appendix 14. Pasture Fertilization yield data for Harvest 3, 1991.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
LIDSTER	1	1	10.7	7.2	3.5	32.71%	118.2	86.1	21.60	258	104.6	0.12
SEPT 12/91		2	11.4	9.2	2.2	19.30%	110.4	84.7	20.74	248	100.4	0.11
		3	20.7	11	9.7	46.86%	151.4	89.8	32.73	392	158.5	0.17
		4	13.3	6.3	7	52.63%	105.8	93	6.06	73	29.4	0.03
		5	4.7	3	1.7	36.17%	97.7	88.2	6.06	73	29.4	0.03
						AVERAGE YIELD				209	84.4	0.09
	2	1	17.5	10.2	7.3	41.71%	132.8	81.2	30.08	360	145.6	0.16
		2	17.9	11.2	6.7	37.43%	120.0	84.8	22.02	263	106.6	0.12
		3	18	8.6	9.4	52.22%	159.4	82.8	36.60	438	177.2	0.20
		4	17.9	10.3	7.6	42.46%	138.6	80.6	33.37	399	161.6	0.18
		5	17.4	6.6	10.8	62.07%	161.2	82	30.04	359	145.5	0.16
						AVERAGE YIELD				364	147.3	0.16
	3	1	18.3	10.1	8.2	44.81%	115.2	83.1	17.72	212	85.8	0.09
		2	15.7	9.2	6.5	41.40%	101.4	79.8	12.66	151	61.3	0.07
		3	20.4	11.8	8.6	42.16%	129.4	83.2	26.72	320	129.4	0.14
		4	11.3	7.7	3.6	31.86%	96.3	77.2	13.02	156	63.0	0.07
		5	12.7	7.4	5.3	41.73%	144.6	78.3	38.63	462	187.1	0.21
						AVERAGE YIELD				260	105.3	0.12
	CHECK	1	7	5.3	1.7	24.29%	91.0	82.1	6.74	81	32.6	0.04
		2	15.3	9.5	5.8	37.91%	99.9	80.2	12.23	146	59.2	0.07
		3	7.6	4.3	3.3	43.42%	167.0	85.7	46.00	550	222.7	0.25
		4	15.1	8.5	6.6	43.71%	126.5	84.2	23.81	285	115.3	0.13
		5	12.9	7.7	5.2	40.31%	113.5	80.3	19.82	237	96.0	0.11
						AVERAGE YIELD				260	105.2	0.12
BLACK	1	1	6.6	5.7	0.9	13.64%	114.6	88.5	22.54	270	109.1	0.12
SEPT 12/91		2	14.1	8.6	5.5	39.01%	165.0	84.3	49.22	589	238.3	0.26
		3	15	11	4	26.67%	130.7	83.4	34.69	415	168.0	0.19
						AVERAGE YIELD				424	171.8	0.19
	2	1	10.1	7.3	2.8	27.72%	120.0	86.8	24.00	287	116.2	0.13
		2	19.6	8.1	11.5	58.67%	240.0	86.1	63.60	761	308.0	0.34
		3	11.2	7.3	3.9	34.82%	155.0	83.2	46.80	560	226.6	0.25
						AVERAGE YIELD				536	216.9	0.24
	3	1	14.2	9.4	4.8	33.80%	144.3	84.2	39.78	476	192.6	0.21
		2	16.7	8.5	8.2	49.10%	169.3	87.5	41.63	498	201.6	0.22
		3	18.5	10.3	8.2	44.32%	150.7	83.6	37.36	447	180.9	0.20
						AVERAGE YIELD				474	191.7	0.21
	CHECK	1	10.1	8.2	1.9	18.81%	108.0	87.9	16.32	195	79.0	0.09
		2	16.3	11.5	4.8	29.45%	185.5	88.9	68.15	815	330.0	0.36
		3	16.5	11.5	14.1	30.30%	136.6	84	36.66	438	177.5	0.20
						AVERAGE YIELD				483	195.5	0.22

Appendix 14. cont'd.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
NICKLEN	BAND	1	8.9	7.8	1.1	12.36%	99.3	79	17.79	213	86.1	0.09
SEPT 12/91		2	4	3.5	0.5	12.50%	83.9	78.9	4.38	52	21.2	0.02
		3	8.7	7.8	0.9	10.34%	91.2	79.7	10.31	123	49.9	0.06
		4	9.8	8.7	1.1	11.22%	90.5	76.7	12.25	147	59.3	0.07
						AVERAGE YIELD				134	54.1	0.06
	CHK 1	1	11.6	10.4	1.2	10.34%	97.1	74.9	19.90	238	96.4	0.11
		2	1	1	0	0.00%	1.0	1	0.00	0	0.0	0.00
		3	6.7	6	0.7	10.45%	89.1	79.7	8.42	101	40.8	0.04
		4	5.3	4.8	0.5	9.43%	89.5	80.9	7.79	93	37.7	0.04
						AVERAGE YIELD				108	43.7	0.05
	1	1	10.6	9.5	1.1	10.38%	102.9	81.6	19.09	228	92.4	0.10
		2	6.7	6	0.7	10.45%	87.7	79	7.79	93	37.7	0.04
		3	1.9	1.7	0.2	10.53%	80.3	77.4	2.59	31	12.6	0.01
		4	4.4	4	0.4	9.09%	84.5	77.4	6.45	77	31.3	0.03
						AVERAGE YIELD				107	43.5	0.05
	2	1	11.7	10.6	1.1	9.40%	96.0	75.5	18.57	222	89.9	0.10
		2	9.9	8.9	1	10.10%	91.5	77	13.04	156	63.1	0.07
		3	3.8	3.4	0.4	10.53%	86.9	80.9	5.37	64	26.0	0.03
		4	5.4	4.8	0.6	11.11%	87.9	80.5	6.58	79	31.9	0.04
						AVERAGE YIELD				130	52.7	0.06
	3	1	10.3	9.2	1.1	10.68%	96.5	80.6	14.20	170	68.8	0.08
		2	9.4	8.5	0.9	9.57%	98.1	80.2	16.19	194	78.4	0.09
		3	8.3	7.4	0.9	10.84%	100.0	81	16.94	203	82.0	0.09
		4	1	1	0	0.00%	1.0	1	0.00	0	0.0	0.00
						AVERAGE YIELD				142	57.3	0.06

Appendix 15. Pasture Establishment Project yield data, 1991.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
RIEMER	1	1	38.7	10.5	28.2	72.87%	286.7	95.1	51.98	622	251.7	0.28
MAY 28/91		2	31.3	8.5	22.8	72.84%	343.5	94.7	67.57	808	327.2	0.36
Oats @ 10#/ac		3	17.9	5.1	12.8	71.51%	361.0	107	72.37	866	350.4	0.39
		4	19.1	5.6	13.5	70.68%	354.4	104.8	73.18	875	354.4	0.39
						AVERAGE YIELD				793	320.9	0.35
	2	1	19.4	5.2	14.2	73.20%	222.0	95.4	33.93	406	164.3	0.18
		2	25	6.6	18.4	73.60%	258.3	106.1	40.18	481	194.6	0.21
Oats @ 2 bus/ac		3	20.1	5.8	14.3	71.14%	251.0	108.8	41.03	491	198.7	0.22
		4	11.3	3.1	8.2	72.57%	200.0	93	29.35	351	142.1	0.16
						AVERAGE YIELD				432	174.9	0.19
	3	1	20.6	6.2	14.4	69.90%	212.5	97.7	34.55	413	167.3	0.18
		2	30.2	7.9	22.3	73.84%	268.0	110	41.33	494	200.1	0.22
Oats @ 1 bus/ac		3	20.5	5.4	15.1	73.66%	224.6	107	30.98	370	150.0	0.17
		4	20.4	5.5	14.9	73.04%	200.5	82	31.95	382	154.7	0.17
						AVERAGE YIELD				415	168.0	0.19
RIEMER	1	1	16.9	5.4	11.5	68.05%	241.6	100.0	45.2	541.1	219.1	0.24
June 19/91		2	17.3	6.4	10.9	63.01%	205.0	97.7	39.7	474.7	192.2	0.21
Oats @ 10#/ac		3	19.1	6.1	13	68.06%	257.0	111.0	46.6	557.7	225.8	0.25
		4	19.9	7.4	12.5	62.81%	236.4	108.5	47.6	568.8	230.3	0.25
						AVERAGE YIELD				535.6	216.8	0.24
	2	1	19.7	5.6	14.1	71.57%	244.5	99.8	41.1	492.0	199.2	0.22
		2	28	10.4	17.6	62.86%	209.2	108.7	37.3	446.4	180.7	0.20
Oats @ 2 bus/ac		3	20.9	6.8	14.1	67.46%	184.3	111.0	23.8	285.2	115.5	0.13
						AVERAGE YIELD				407.9	165.1	0.18
	3	1	21	7.5	13.5	64.29%	192.6	98.6	33.6	401.5	162.6	0.18
		2	18.6	7.1	11.5	61.83%	225.1	110.2	43.9	524.6	212.4	0.23
Oats @ 1 bus/ac		3	20	6.5	13.5	67.50%	211.0	109.5	33.0	394.5	159.7	0.18
						AVERAGE YIELD				440.2	178.2	0.20

Appendix 15. cont'd.

PLOT	TRTMT	REP	WET WT	DRY WT	LOSS	% MOIST	GROSS WT	BAG WT	DRY WT	DM KG/HA	DM KG/AC	DM T/AC
RIEMER	1	1	15.8	3.8	12.0	75.95%	202.7	97.5	25.3	302.6	122.5	0.14
July 9/91		2	20.2	4.9	15.3	75.74%	233.1	97.0	33.0	394.9	159.9	0.18
Oats @ 10#/ac		3	18.2	4.6	13.6	74.73%	259.8	109.3	38.0	454.9	184.2	0.20
		4	25.5	6.0	19.5	76.47%	297.0	105.6	45.0	538.6	218.1	0.24
						AVERAGE YIELD				422.8	171.2	0.19
	2	1	19.3	4.9	14.4	74.61%	252.7	97.7	39.4	470.7	190.5	0.21
		2	26.2	6.3	19.9	75.95%	252.3	108.0	34.7	415.0	168.0	0.19
Oats @ 2 bus/ac		3	21.0	5.2	15.8	75.24%	292.2	110.0	45.1	539.6	218.5	0.24
		4	23.7	6.3	17.4	73.42%	292.3	90.5	53.6	641.6	259.7	0.29
						AVERAGE YIELD				516.7	209.2	0.23
	3	1	20.7	5.3	15.4	74.40%	218.6	98.9	30.6	366.5	148.4	0.16
		2	25.2	6.9	18.3	72.62%	241.7	112.1	35.5	424.4	171.8	0.19
Oats @ 1 bus/ac		3	23.7	6.5	17.2	72.57%	221.1	108.6	30.9	369.0	149.4	0.16
		4	20.1	5.6	14.5	72.14%	269.0	84.2	51.5	615.8	249.3	0.27
						AVERAGE YIELD				443.9	179.7	0.20
RIEMER	1	1	17.5	6.9	10.6	60.57%	201.1	102.8	38.8	463.5	187.7	0.21
Sept 12/91		2	14.3	7.0	7.3	51.05%	281.6	101.2	88.3	1056.2	427.6	0.47
Oats @ 10#/ac		3	16.2	7.8	8.4	51.85%	256.0	110.0	70.3	840.7	340.4	0.38
		4	20.2	8.7	11.5	56.93%	347.5	105.6	104.2	1246.0	504.5	0.56
						AVERAGE YIELD				901.6	365.0	0.40
	2	1	19.0	7.7	11.3	59.47%	281.0	97.0	74.6	891.8	361.1	0.40
		2	18.3	8.3	10.0	54.64%	288.5	108.1	81.8	978.6	396.2	0.44
Oats @ 2 bus/ac		3	14.2	5.8	8.4	59.15%	283.0	100.4	74.6	892.0	361.1	0.40
		4	14.5	9.0	5.5	37.93%	271.1	90.0	112.4	1344.4	544.3	0.60
						AVERAGE YIELD				1026.7	415.7	0.46
	3	1	14.7	8.1	6.6	44.90%	171.5	99.0	39.9	477.8	193.4	0.21
		2	16.2	8.0	8.2	50.62%	198.2	111.8	42.7	510.3	206.6	0.23
Oats @ 1 bus/ac		3	15.1	5.9	9.2	60.93%	297.2	108.9	73.6	879.9	356.3	0.39
		4	18.5	8.4	10.1	54.59%	411.5	82.5	149.4	1786.6	723.3	0.80
						AVERAGE YIELD				913.7	369.9	0.41